NATIONAL MUSEUM OF VICTORIA

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PAPERS AND PROCEEDINGS

OF

The Royal Society of Tasmania

Volume 88

NATIONAL MUSEUM OF VICTORIA

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Royal Society of Tasmania

Volume 88

Annual Report

AND

Proceedings

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The Royal Society of Tasmania

Volume 88

Patron:
Her Majesty the Queen.

President:
His Excellency Rt. Hon. Sir Ronald Cross, Bt.

Vice-Presidents:
L. W. Miller, M.Agr.Sc., F.R.E.S., from May, 1952, 1953.
S. Angel, till April, 1955.

Council:
J. W. C. Wyett, B.Sc., A.A.C.I., 1953, 1954, 1955.
F. C. Wolfhagen, LL.B., 1953, 1954, 1955.
H. N. Barber, M.A., Ph.D., 1953, 1954.
I. G. Anderson, F.R.S.A. (Lond.), 1953, 1954.
S. W. Carey, D.Sc., 1953.
C. Bisdee, 1953.

Hon. Secretary and Librarian:
D. Martin, M.Sc.

Hon. Treasurer:
G. E. A. Hale, B.Sc.

Hon. Auditor:
A. M. Hewer.

Hon. Editor of the Papers and Proceedings:
D. Martin, M.Sc.

Standing Committee:
J. W. C. Wyett, L. W. Miller, H. N. Barber, D. Martin.

Annual Report, 1953

The Annual Meeting was held in the Society's Room, Tasmanian Museum, on 3rd March, 1953.

Mr. J. W. C. Wyett, Vice-President, presided.

The following Office-Bearers were elected:—

Vice-President: Under the Society's Rules Mr. J. W. C. Wyett retired from the office of Vice-President, and Mr. S. Angel was appointed in his place (retiring 1955).

Hon. Secretary and Librarian: Mr. D. Martin.

Hon. Treasurer: Mr. G. E. Hale.

Hon. Auditor: Mr. A. M. Hewer.

Council: Under Rule 21 Dr. W. L. Crowther and Mr. M. S. R. Sharland retired as members of the Council and Mr. J. W. C. Wyett and Mr. F. C. Wolfhagen were elected in their place for a period of three years.

The names of the full Council for 1953 are given on the previous page.

The Council made the following appointments at its first meeting:—

Standing Committee: Mr. J. W. C. Wyett, Mr. L. W. Miller, Professor H. N. Barber and the Hon. Secretary.

Board of Trustees of the Tasmanian Museum, and Board of Trustees of the Botanical Gardens:

Board of Trustees of Tasmanian Museum: Professor T. Hytten and Professor A. Burn.

Board of Trustees, Botanical Gardens: Mr. S. Angel.

Meetings: Nine ordinary meetings and one special meeting were held during the year. The special meeting was held on 1st December as the Society's contribution in the Sesquicentenary Celebrations of the State. The President, His Excellency the Governor, Sir Ronald Cross, presided, and Mr. Robert Sharman, State Archivist, delivered a lecture entitled "Immigration One Hundred Years Ago". The opportunity was taken to present Dr. Joseph Pearson with a Travelling Clock and cheque for £111 as a token of gratitude and esteem from the members of the Royal Society and from the Friends of the Museum. Supper was served in the Fine Arts Room at the Museum to approximately 260 members and friends. Special guests at the meeting were: Lady Cross, the Hon. State Director of the Sesquicentennial Committee (Mr. G. E. Walch) and Mrs. Walch, the President of the Legislative Council (Sir Rupert Shoobridge) and the Lord Mayor and Lady Mayoress.

Library: During the year 415 volumes were added to the Library in addition to a number of reports and pamphlets from British and Foreign Institutions and learned societies. The number of institutions on the exchange list is 272. The Library now consists of 29,499 volumes.

Changes in Staff: The transfer of Miss J. Robertson from the staff of the Royal Society to that of the University at the end of 1952 left the Library without a Cataloguer. However, after consultation with the Vice-Chancellor of the University, arrangements were made to continue payment of the salary of a catologuer by the University and Miss D. Bulman, the Assistant Librarian in the Society's Library, was appointed to that position. Miss Alicia Miller joined the staff as Assistant Librarian in Miss Bulman's place on 30th April. The Council wishes to record its grateful thanks to the University for its continued assistance in the important work of cataloguing the Library.

Retirement of Dr. J. Pearson: Dr. J. Pearson, who had held the position of Hon. Secretary to the Society for 19 years resigned in March and Mr. D. Martin, formerly Assistant Hon. Secretary, was appointed to act in his place. Mention was made at the General Meetings held on 3rd March and 1st December of this year of the outstanding work done by Dr. Pearson during his term of office (see report of Proceedings on these dates for further information).

Mr. S. Angel: At the Annual General Meeting on 3rd March Mr. S. Angel was elected a Vice-President and relinquished the post of Hon. Treasurer of the Society, which he had held since 1933. Mr. Angel's advice on financial matters and the time he has so willingly given have been much valued by the Council and they wish to record their appreciation of Mr. Angel's service to the Society.

Membership: The Society consists of the following members:—

Honorary Members		3
Corresponding Members		1
Ordinary Members:		
Class A	256	
Class B	158	
	—	414
Life Members		30
Associate Members		23
TOTAL		471

During the year 31 names were removed from the list of Members owing to deaths, resignations, &c., and 48 new members were elected.

Deaths: The Council regrets having to record the deaths of the following persons:—Mrs. G. H. Butler, Mr. W. H. Clemes, Dr. Stuart Gibson, Mr. H. B. Hood, Miss M. Hookey, Professor G. E. Nicholls, Mr. K. L. Shoobridge, Mr. H. G. Vaughan.

Mr. W. H. Clemes: Mr. Clemes had been a member of the Royal Society for a number of years and had given valuable service in the office of Vice-President and as a member of the Council. He had also contributed papers for publication in the Journal. In Mr. Clemes' passing the Society has suffered a very great loss.

W. H. Hudspeth Memorial: The last annual report referred to the decision made at a meeting of subscribers to the W. H. Hudspeth Memorial Fund on 2nd December, 1952, to publish "Profile of a Pioneer" as a memorial volume to Mr. Hudspeth. Mr. R. Sharman, who had kindly consented to edit "Profile of a Pioneer" stated that on going into the matter he felt this was an unsatisfactory memorial as at least two-thirds of the paper dealt with material outside Tasmania and also that the paper was not of sufficiently high historical value to warrant its being published as a memorial. The Committee met and finally decided to recommend to the subscribers that the Hudspeth Memorial Volume should consist of the following:—

(*a*) A Memoir of the late W. H. Hudspeth with photographs.

(*b*) Mr. Hudspeth's notes on the Knopwood Diary with a picture of Rev. Robert Knopwood.

(*c*) A reprint of Mr. Hudspeth's "Leaves from the Diary of a Van Diemen's Land Official" (Mr. Boyes), which has already been published by the Royal Society of Tasmania in the Papers and Proceedings for 1946.

The subscribers, with few exceptions, agreed to the change and the volume is now in preparation for printing.

Bequest: The late Miss Mabel Hookey bequeathed to the Society her copy of "The Diary of Rev. Robert Knopwood, Jan. 1805-April 1806".

Gift: Mr. John Hudspeth presented to the Society the historical papers brought together by his father, the late Mr. W. H. Hudspeth.

Papers and Proceedings: The whole question of the rising costs in printing the Society's Papers and Proceedings was reviewed by the Council during this year and a small deputation waited on the Acting Premier and discussed with him the matter of an increase in the Government Grant for printing. As a result of this interview the Government has decided to make available during the next three years an amount up to £550 per annum to meet the cost of printing the journal. The Council wishes to record their grateful thanks for this generous action.

There was also an outstanding amount of £122 3s. 6d. owing on the 1951 volume. This has been met by an additional amount of £75 being made available by the Government and a contribution of £47 3s. 6d. by the Committee of the Tasmanian Biological Survey. This financial assistance is very much appreciated.

The Council also would record its thanks for the help given by the University in providing the sum of £250 in its Estimates towards the publication of papers in the Papers and Proceedings by members of the University Staff.

Royal Society of Tasmania

Statement of Receipts and Payments for Year Ended 31st December, 1953.

GENERAL FUND

RECEIPTS			£ s. d.
Balance from last account			19 5 0
Subscriptions:			
252 @ £2 + £12 12s.	£516 12 0		
146 @ 30/- + £1 1s.	220 1 0		
24 @ 15/-	18 15 0		
1 @ £25	25 0 0		
			780 8 0
Sale of publications			62 4 11
Rentals			50 7 6
Refunds			30 7 7
Purchase of books, 1952:			
A. N. Lewis Memorial	£6 14 0		
Clive Lord Memorial	12 15 6		
			19 9 6
Purchase of books, 1953:			
Morton Allport Memorial	£7 14 5		
A. H. Clarke Bequest	2 19 5		
Milligan Bequest	2 16 9		
			13 10 7
			£975 13 1

PAYMENTS	£ s. d.
Salaries	253 19 8
Library	123 3 7
Lecture expenses	28 9 1
Stationery, printing and advertising	41 16 1
Papers and Proceedings (postage, 1951 and 1952)	44 1 4
Northern Branch, share subs. (1952)	80 7 6
Reserve Fund (sale publications, 1952)	51 16 3
Life Membership Fund, Mrs. Dumaresq, Life Membership fee	25 0 0
Light and power	88 13 5
Miscellaneous	12 15 2
Insurance	27 7 6
Petty cash (in hand, 31.12.53, £1 1s. 3½d.)	93 0 0
Balance to next Account	105 3 6
	£975 13 1

G. E. Hale, Hon. Treasurer.
A. M. Hewer, Hon. Auditor.

L. W. Miller, Vice-President.
D. Martin, Hon. Secretary.

Royal Society Funds

Statement of Balances for Year Ended 31st December, 1953.

	£	s.	d.
Reserve Account (includes £100 bequest, W. H. Hudspeth)	200	10	4
Life Membership	312	16	7
Clive Lord Memorial Fund (£200)	8	2	11
R. M. Johnston Memorial Fund (£232)	7	6	1
Morton Allport Memorial Fund (£200)	0	6	3
A. H. Clarke Bequest (£100)	0	7	3
Milligan Bequest (£150)	2	4	1
A. N. Lewis Memorial Fund (£250)	32	10	8

NORTHERN BRANCH

Annual Report, 1953

At the Annual Meeting of the Royal Society of Tasmania (Northern Branch) held at the Museum on April 18th, 1953, the following office-bearers were elected under the rules of the Society:—

Chairman: Mr. K. R. von Stieglitz.

Vice-Chairman: Mr. G. C. McKinley.

Council: Dr. C. Craig, Mr. J. R. Heritage, Mr. R. Smith, Mr. G. Willing, Mr. J. Rex.

Hon. Secretary and Treasurer: Miss I. Thomson.

Upon her marriage, Miss Thomson resigned, and Mr. W. F. Ellis was appointed Acting Hon. Secretary/Treasurer.

Meetings: During the year, seven Council meetings were held, and at the seven General Meetings, the following papers were read:—

May 15: "Yellow Gums and Black Rabbits", by Prof. H. N. Barber.

July 1: "The Hentys and the Colonial Office in the 1830's and 1840's, by Mrs. M. Bassatt.

Aug. 24: "The Australian Aborigine and Linguistics", by Dr. A. Capell.

Sept. 14: "Investigations on Scallops", by Mr. M. Olsen.

Oct. 11: Recordings of broadcasts made by the late W. H. Hudspeth on Tasmanian History.

Nov. 20: "A Journey to Ayers Rock", by Dr. W. Bryden.

Feb. 18: "Vandiemonian Settlers in Port Phillip", by Miss M. Kiddle.

Membership: The present membership stands at:—13 life members, 126 ordinary members, 13 associate members. Thirty-three new members joined through the year, and six resigned or were transferred to the general body of the Society.

Library: Approximately five books have been added to the Library.

Donations: The following donations were made to this Branch:—

Manuscript of lecture on early Tasmania, by Dr. Kilgour, presented by Mr. H. W. A. Kilgour, Cheltenham, England.

Notes on the history of Launceston prepared and presented by Mr. W. Gellie.

Sesquicentenary Celebrations: To commemorate this occasion, the Northern Branch will shortly be issuing a specially prepared edition of T. J. Lempriere's "Penal Settlements in Van Diemen's Land". This work has been transcribed from the original manuscript held at the Mitchell Library by kind permission of the Trustees.

The Northern Branch have also combined with several other organisations in initiating other commemorative projects. A series of lectures on Tasmanian history are to be presented by the Adult Education Board under the auspices of the Society, beginning in May, but unfortunately other projects such as the memorial to William Collins and the Reserve at Yorktown have not yet been successfully concluded.

It is hoped that some permanent record of this anniversary will be prepared before the end of the centenary year next November.

Royal Society of Tasmania

(Northern Branch)

Statement of Accounts at 31st December, 1953

RECEIPTS	£	s.	d.
Balance at 1.1.53	60	15	5
Subscriptions	80	7	6
Interest	1	16	3
	£142	19	2

EXPENDITURE	£	s.	d.
Lectures	8	7	0
Library	28	7	3
Printing and advertising	15	5	10
Postage and petty cash	11	17	4
Photostat Lempriere manuscript	12	6	9
Balance forward	66	15	0
	£142	19	2

F. ELLIS, Acting Hon. Sec./Treasurer.

J. R. FORWARD, Auditor.

Abstract of Proceedings

3rd March, 1953

Annual Meeting

The Annual Meeting was held in the Society's Room, Tasmanian Museum. Vice-President, J. W. C. Wyett, presided.

The following Office-bearers were elected for 1953:—Mr. S. Angel was elected Vice-President in the place of Mr. J. W. C. Wyett who retired under Rule 12; Honorary Secretary, Mr. D. Martin; Honorary Treasurer, Mr. G. E. Hale; Honorary Auditor, Mr. A. M. Hewer.

The following were elected members of the Council:—Mr. J. W. C. Wyett and Mr. F. C. Wolfhagen were elected for three years in place of Dr. W. L. Crowther and Mr. M. S. R. Sharland, who retired under Rule 21.

The following were elected members of the Society:—Mr. G. H. Hill, Mr. W. E. Senior, Dr. R. J. D. Turnbull.

The Chairman reported the death of Admiral Sir Hugh Binney, who was formerly President of the Society, and Dr. Crowther moved that a message of condolence be sent to Lady Binney from the Society.

Brigadier Dollery delivered an illustrated lecture entitled "The Military Aspect of Tasmanian History with particular reference to Anglesea Barracks", of which the following is an abstract:—

> Whenever we delve into the past in an examination of Tasmanian history we should endeavour to create the atmosphere of the period under review. It is only by thus relating events to the laws, customs and general outlook of the times in which they occurred that they can be seen in their true perspective.
>
> This is particularly necessary in a consideration, for instance, of the Convict System as it operated in Tasmania in the early years of the last century.
>
> Colonisation would not have been practicable without the employment of the armed forces of Great Britain. They were called upon to form the administrative backbone of our settlements, in that they were utilised to maintain law and order, provide guards and overseers for the forced labour found from the convict system, protect the community against attack by hostile natives, undertake public works of all natures, and in general to carry out multifarious duties entirely unconnected with and foreign to their normal avocation as professional sailors or soldiers. All these things they somehow managed to do with remarkable success and unexpected ability, always remembering that the standard of education of the man in the ranks in those days was exceedingly low judged by modern standards.
>
> All over Tasmania may be found roads and bridges and buildings constructed under the supervision of officers of Line Regiments with little or no previous experience or training in this type of work.
>
> Finally, many of these men took their discharge in the Colony and took up land or went into business in the growing settlements throughout the Island, founding families whose descendants remain to this day.

The first impact of the armed forces of the Crown on the history of Van Diemen's Land is provided by the settlement at Risdon in 1803, when a young Naval officer, Lieut. John Bowen, landed with but eight men of the New South Wales Corps to assist him in controlling the convicts allotted to his force, and in the many problems associated with the founding of a community in a virgin country. This small coterie was later augmented from Sydney, but it should be remembered that their calibre was not particularly high, the New South Wales Corps possessing the unenviable reputation of being probably the worst set of men ever gathered together into one of His Majesty's Regiments.

Next we find the Royal Marines arriving with Lieut. Colonel David Collins in 1804, as his backstop in the new settlement at Sullivan's Cove. This now famous Corps had but recently been raised in 1802.

From that time our Military History falls into three main eras, the British Garrisons 1803-1870, the Local Volunteer Forces 1860-1901, and the Commonwealth Military Forces from 1901 to the present time.

During the 67 years in which the Mother Country provided the garrisons throughout the Island, no less than twenty-one Regiments of the Line served here, many of them amongst the most famous in British history. To these we must add the Royal Marines and the Royal Engineers.

There are many highlights of those early days on which I could dwell if time permitted, some of them fascinating, some most amusing, some distinctly of a disastrous nature.

I quote just a few examples from records. The first which comes to mind is the firing of two cannon at Risdon in 1803 at a party of natives and the resultant unwarranted killing of several of them. This incident was doubtless born of a panic decision, which was the commencement of the hostility between the original inhabitants of this Island and the white settlers which dragged on for many years until ended by the extinction of the former.

In 1806 the news of Trafalgar filtered out to the infant colony, and the victory was duly celebrated by the hoisting of the flag and the firing of guns.

1807 saw Lieut. Laycock, of the N.S.W. Corps, make his epic journey on foot, with four men, from Launceston to Hobart and back, the forward journey taking only seven days.

In 1815 we find the first declaration of Martial Law by Lieut. Governor Thomas Davey, directed against the bushrangers, who had become a menace to life and property. This was to be followed in 1826 by a similar campaign of greater scope, under Governor Arthur's direction.

Then the notorious and humiliating so-called "Black War" of 1830, when 1,000 soldiers of four regiments and 1,500 armed civilians under Arthur's personal leadership, entirely failed to round up the few remaining natives in the Island.

The temporary absence of all troops on this fortuitious task led to the raising of Volunteer Guards to protect the communities in Hobart Town and Launceston. This is the first instance of an armed Militia in the Island's history.

Arthur's scheme for a model convict settlement at Port Arthur, 1830-1878, would not have been practicable but for the employment of soldiers as administrators and guards.

In 1836, Capt. William Turner, of the Royal West Kents, completed the well known stone viaduct bridge at Ross.

1853 brought the long sought cessation of transportation, leading to a considerable reduction in the military strength of the Colony.

And in 1870 the last British Regiment to serve in Tasmania, the Royal Irish, marched to their ship at Princes Wharf with the band playing "The Girl I left Behind Me". The first Regiment to be stationed here was the 73rd, afterwards the famous Black Watch, which was, incidentally, Macquarie's Regiment.

Finally, there is the incident involving the officers of the 46th Regiment (1814-1818) who were somewhat autocratic and over-bearing, notably when, having received an invitation to dine with the Governor (Davey), they neglected to tender their acceptance of the courtesy. On the morning of the dinner party the Governor's Private Secretary called to enquire why no answer had been received, and was informed that the Governor was not worth the purchase of a new pair of white gloves. Macquarie wrote the War Office to the effect that a taste of active service might have a salutary effect on these gentlemen, and in due course the regiment was ordered to India.

Th first Volunteers were raised in Tasmania in 1860, under an Act passed in 1858, and consisted initially of Artillery and Infantry Companies in the South and North of the Island. Their uniforms were most colourful and most unsuitable, and they received no pay for their services. For some years they had the benefit of instruction and training by the British garrisons, and some of the Regular Officers remained in the Colony to take over this duty. The Volunteers suffered many vicissitudes, and in the 70's were shockingly neglected by the Government, leading to almost complete extinction. The Russian scares of 1878 and 1885 led to a revival in the Volunteer movement, and by the end of the century there was a relatively small but efficient body of men available for transfer to Commonwealth control. Tasmania was at this time first represented in war by a detachment of Mounted Infantry known as Imperial Bushmen, which served with credit in South Africa, gaining two Victoria Crosses.

Batteries, all now abandoned, built to defend Hobart were Mulgrave (Castray Esplanade), Queen's (Domain), Alexandra (Sandy Bay), Bluff (Bellerive) and Fort Nelson (Mt. Nelson).

In 1878 occurred the only instance of armed Militia Forces in Tasmania being called out for the maintenance of law and order. This was on the outbreak of the Chiqique Riots, when the Local Forces, 300 strong, were mobilised with five rounds of ammunition on each man.

The Headquarters of the Military Forces in Tasmania, Anglesea Barracks, has a unique history, dating back to 1811. It is one of the two oldest existing barracks in Australia, the other being the Lancer Barracks at Parramatta, N.S.W.

During the time of Collins, the troops were quartered very uncomfortably in wattle and daub huts in the town, in an area now roughly bounded by Macquarie, Murray, Collins and Harrington Streets, and known as Marine Square.

When that indefatigable and efficient administrator, Governor Lachlan Macquarie, arrived from Sydney in 1811 to make an inspection of his infant Colony, he was immediately concerned with the sub-standard nature of the military quarters, and set about correcting this with his usual enthusiasm and drive.

On 2nd December that year he rode out in the morning with his A.D.C., Capt. Antill, from Government House, then situated in Franklin Square, and mounting to the top of a small rise about one and a half miles south-west of the settlement he stopped and surveyed the magnificent all round view it afforded. "This", he said, "is the spot for a Barracks". Thus, was Anglesea Barracks first conceived, and the hill was called Barrack Hill from that day.

The garrison at that time was formed by a detachment of the 73rd, Macquarie's own regiment, so his concern for their welfare would be all the more natural.

Macquarie ordered the Inspector of Works to commence the assembling of the necessary materials for constructing a barrack to house 150 men, with officers' quarters and a small hospital, and on his return to Sydney he followed this up with written instructions and specifications and repeated enquiries as to what progress was being made. History is not clear as to the exact dates these buildings were begun, and the first authentic record is found in

Knopwood's diary for 17th August, 1814, where he describes the laying of the foundation stone of the officers' quarters by the Lieut. Governor, Col. Thomas Davey. This building is still in use, and is known as "K" Block. Incidentally, Knopwood notes that the ceremony was attended by the Masons. These would be members of the "Lodge of Social and Military Virtues", attached to the 46th Regiment, and it was from this lodge that the present Grand Lodge of Tasmania took its rise, representing the dawn of Freemasonry in Tasmania.

On 5th November, 1814, Knopwood records the holding of Divine Service at the Barracks, and on other subsequent occasions, prior to the building of a Church in the township.

It is thought that the Barracks was named by Governor Arthur after Henry William Paget, Marquis of Anglesey, later Earl of Uxbridge, who was a personal friend of Arthur's and Master-General of the Ordnance during the 1820's. "Anglesea" is an alternative spelling for the Island of that name in the United Kingdom.

At the Barracks there is that most interesting feature, the 99th Regiment Monument. It is the only memorial in Australia erected by British troops to the memory of their comrades who fell on active service. The 99th, now the Wiltshires, were serving in New South Wales when the Maori War broke out in 1845. They sent a contingent to New Zealand, which served with distinction. The 99th was moved later to Tasmania, where they served from 1848 to 1856, and in the year 1850 this freestone pillar was set up by subscriptions from members of the Regiment. Its centenary was celebrated in 1950, and the Wiltshire Regiment sent out a plaque which is affixed to the base of the column.

14th April, 1953

A meeting was held in the Society's Room. Mr. L. W. Miller, Vice-President, presided.

The following were elected members of the Society:—Dr. A. M. Thynne, Mr. W. Ellis Cox, Mr. K. W. Dillon, Brigadier G. E. Hurley, Mr. H. H. McFie, Mr. L. E. Murray, Mr. I. Rowley, Mr. G. Hale, Mrs. E. Cleaver, Mr. F. Ikin, Mr. P. Mercer, Mr. A. Smith, Mr. W. A. Wright, Mrs. W. A. Wright.

Mr. K. D. Nicholls delivered an illustrated lecture entitled "Soil Formation on Dolerite", of which the following is an abstract:—

The first part of the address dealt in a general way with the fundamental principles of pedology and introduced the concepts involved in the second part. If one of the factors of soil formation is constant over a range of soils, attention can be more easily focussed upon the remaining factors to study their effects. In Tasmania this can be done by considering the range of soils formed on one parent material, dolerite, which is widespread in a number of different environments. Five groups of soils, their distribution over the State, and the environments in which they are found were discussed and the profiles of typical soils were illustrated with colour photographs. These groups, arranged in order of increasing severity of leaching are the black earths, brown earths, grey-brown podzolics, red loams, and high moor peats. In alpine areas deep soils formed on glacial and periglacial deposits of material derived from dolerite are widespread, and may or may not have a surface horizon of peat. The grey-brown podzolic soils and the alpine soils are the most extensive.

12th May, 1953

A meeting was held in the Society's Room. Mr. L. W. Miller, Vice-President, presided.

The following were elected members of the Society:—Mr. B. G. Dent, Mr. J. W. Lyne, Dr. A. E. Stuart, Mrs. N. P. K. Lyne.

Professor K. G. Brill delivered an illustrated lecture entitled "Cliff Dwellers of South Western United States" of which the following is an abstract:—

> The Cliff Dwellers were a group of North American Indians which lived in and around Mesa Verde in what is now south western Colorado. They attained the highest cultural development of any pre-Columbian Indian tribe in the present area of the United States.
>
> A rather remarkable cultural evolution took place over a period of about 500 years. These Indians first made their homes in rock shelters in the sandstone cliffs of Mesa Verde. Later they moved to the top of the Mesa where they built homes of timbers and adobe (sun-dried mud). They cultivated maize, squash and yams. At a still later date, presumably as a measure of defence, the tribe moved back to the rock shelters. Here they built rather elaborate walls and buildings of stone and timbers plastered with adobe. Some of the buildings are four storeys high. The subterranean ceremonial chamber (kiva) is characteristic of the ruins.
>
> The tribe lived in these cliff dwellings for about 40 years, but abandoned them about 1299 A.D. Mesa Verde was abandoned by the Indians because a 27-year drought made the area unsuitable for the cultivation of crops. It was never reoccupied by Indians.
>
> The movements of the tribe can be dated rather accurately by means of tree-ring chronology.
>
> This paper is not the product of the writer's field research.

9th June, 1953

A meeting was held in the Society's Room. Mr. L. W. Miller, Vice-President, presided.

The following were elected members of the Society:—Mr. P. Scott, Miss M. B. Record, Miss G. T. Thirkell, Mr. C. F. M. Green, Mr. B. H. Travers.

Mr. A. M. Olsen delivered an illustrated lecture entitled "Some Facts about Scallops from Diving Investigations", of which the following is an abstract:—

> Scallops are not peculiar to Tasmania for they support extensive fisheries in U.S.A., Canada, Japan, British Isles and France. Tasmania's total catch of scallops (160 tons in 1952) is greater than that for the British Isles and France, but it is only 1/50 of that of the annual American production of 20 million lbs. weight. In the U.S.A. only the muscle is sold and the roe which represents approximately 25 per cent of the edible portion of the scallop is discarded.
>
> There are three species of scallops in the Tasmanian catch, the predominant species being *Notovola meridionalis*, the commercial scallop, the other two species being the Queen, *Equichlamys bifrons* and the Doughboy scallop, *Mimachlamys asperrimus*. The various overseas scallop fisheries operate on different species.

In Tasmania it has been found that the scallops require at least five years to reach the minimum legal size although they attain sexual maturity in their third year. Contrary to general opinion scallops rest on their curved shell. When making their peculiar swimming movement water is ejected forcibly from the slits between the two valves near the hinge and they are thus propelled forward. Their jet propelled swimming action has the appearance of a series of biting movements through the water. At each bite they move forward about the equivalent of their own length. They have been observed to travel a maximum distance of 15 feet and to rise as high as 6 feet off the bottom.

The scallops are randomly distributed in any one area though the concentration per square yard may fluctuate. The maximum concentration observed was 30-36/sq.yd. among juveniles whilst 6-8 adults/sq.yd. was considered to provide very profitable fishing. Two scallops to the square yard is the lowest concentration which can be worked economically provided a high return of meat from each scallop may be obtained.

The diving methods and techniques used for assessing the population of scallops were described and an actuality sound recording of the diver's reports made by the Australian Broadcasting Commission was played to the meeting.

7th July, 1953

A meeting was held in the Society's Room. Mr. L. W. Miller, Vice-President, presided.

The following members were elected:—Mr. W. H. Furness, Mr. F. J. W. Swann.

The Chairman reported that representatives of the Council had interviewed the Acting Premier concerning the grant for the printing of the Papers and Proceedings. As a result the Government had agreed to contribute a sum of up to £550 for the next three years. Appreciation was expressed of the Government's generous action.

Mr. C. Bisdee delivered an illustrated lecture entitled "Some Recent Astronomical Developments" of which the following is an abstract:—

One of the most important discoveries made in recent years was a satisfactory explanation of how our sun and stars are able to give out such tremendous amounts of energy. We now know that this energy is produced from thermonuclear reactions based on a cycle called the Carbon-Nitrogen cycle. Briefly the cycle consists in the transformation of four protons into one alpha particle plus kinetic and radiation energy. The Carbon and Nitrogen atoms are recovered in their original form and are used as catalysts only. The mass lost in the transformation is given out in energy in accordance with Einstein's fundamental expression Energy, equals Mass multiplied by the velocity of Light squared.

Another very important discovery was radio waves coming in from interstellar space from the annihilation of atoms in stars and nebulae. More recently radio waves have been picked up from the wave energy given out by the annihilation of the hydrogen floating around in interstellar space. Large radio telescopes are now built to pick up the direction and intensities of these radiations coming in on very short wave lengths. Australia is one of the world's leaders in this field.

The development of large reflecting telescopes up to 200 inches diameter and the Schmidt telescope for very fast photographic work on faint stars and nebulae were also discussed, and were followed by two films, one on the 200-inch telescopes on Mt. Palomar, U.S.A., and the other on Radiophysics from the C.S.I.R.O. in Sydney.

4th August, 1953

A meeting was held in the Society's Room. Mr. L. W. Miller, Vice-President, presided.

The following were elected members of the Society:—Capt. R. J. Downie, Mr. H. A. Bartlett, Miss E. D. Dumaresq, Mr. I. Headlam, Mrs. M. Northey, Mr. H. McLeod Ferguson, Mr. K. T. Headlam, Rev. W. E. Northey.

Mr. E. R. Pretyman delivered a lecture entitled " Pirates of Recherche Bay ". (See p. 119.)

1st September, 1953

A meeting was held in the Society's Room. Mr. L. W. Miller, Vice-President, presided.

The following were elected members of the Society:—Mrs. M. A. Wilson, Mr. P. H. Wilson, Mrs. P. M. Archer, Mrs. M. Gatenby, Mr. F. W. Needham, Mr. L. E. Bath, Mr. R. M. Green, Mr. R. C. Kershaw, Mr. D. F. Wicks.

The following exhibits were shown:—

(*a*) Diary of Rev. Robert Knopwood, Jan. 1805—April 1806; bequeathed to the Society by Miss Mabel Hookey.

(*b*) Silver Salver, formerly the property of Hon. G. T. Gregson: bequeathed to the Tasmanian Museum by Miss M. Hookey.

Mr. D. H. Borchardt delivered a lecture entitled " Some Aspects of Early Printing and the Advancement of Learning ", of which the following is an abstract:—

> A short survey of the earliest known types of printing and their spread from China to Europe. The relation between manuscript and print from 1450 to 1500 as evidenced by printer's notes in the Mainz Psalter and in the Catholicon. The material and didactic advantages of print and the attitude of the contemporaries of printing to the new invention. The economic position of authors and printers before 1500. Data concerning scientific incunabula: 3,000 of these, or one book in every twelve published before 1500. List of twelve best sellers and of the twelve most popular authors with brief evaluation of their relative means from the scientific point of view. Brief survey of copyright and privileges and the effects of religious persecution.

5th October, 1953

A meeting was held in the Society's Room. Mr. L. W. Miller, Vice-President, presided.

The following was elected a member of the Society:—Mr. B. C. Clark.

The following exhibits were shown:—" The Story of Launceston and surrounding Districts in Tasmania ", gift from Alderman W. Gellie, Launceston.

Diary of James Belbin, 1808-1810: Gift from Mr. L. S. Rogers.

Mr. P. Scott delivered an illustrated lecture entitled "Some Aspects of Apartheid in Southern Africa", of which the following is an abstract:—

Among the important independent nations South Africa stands alone in the racial composition of her population. At the 1951 census, only 2,643,187 out of a total population of 12,646,375 belonged to the dominant European group, whereas no less than 8,535,341 were returned as Africans, 1,102,323 as Cape Coloureds, and 365,524 as Asiatics. Although each group exhibits considerable ethnic admixture and is difficult to define ethnologically, it is symptomatic that Europeans, however defined, are outnumbered by about four to one. In an attempt to solve a domestic problem for which there is no precedent elsewhere, the South African Nationalist Government has adopted a policy of apartheid, or complete segregation, territorial, social, and political, of white from non-white. Such a policy has found favour among many white South Africans because of the progressive deterioration in the numerical relationship of Europeans to non-Europeans during the past two decades—a deterioration which has been especially marked in urban areas as a result of increasing industrialization and the consequent influx of non-Europeans from rural areas.

However, the principle of racial segregation, if not the present apartheid policy, has long held the support of most white South Africans, English-speaking and Afrikaans-speaking alike. For more than half a century it has found expression in rural areas in the pattern of native reserves and in urban areas in the growth of housing estates and municipal townships designed exclusively for Europeans, or Coloureds, or Africans. The Indian community, virtually synonymous with the group designated "Asiatic" in the census, is the one element in the multi-racial population of South Africa which has not congregated to form distinct ethnic quarters in most towns and cities, largely because of its role as small-scale traders and dealers.

Under the Group Areas Act of 1950, aimed primarily at regulating the racial pattern in urban areas, each ethnic group may reside or own property only within specified districts. Although the enforcement of this Act will cause much personal hardship, owing to the present intermingling of white and non-white in areas marginal to compact ethnic quarters, it merely accelerates the trend towards residential segregation that has been increasingly evident so far this century. But far more important in the long run may be the check it provides to the spread not of non-Europeans into European districts but of non-European slums outwards from the residential zones surrounding the centres of South African cities. For the urban distribution of white and non-white closely resembles that of wealthy and poor in Western cities, but it is accompanied by far greater contrasts in the density and growth of population and hence in standards of living and health. A policy of crystallizing ethnic areas may thus help to improve race relations by controlling, if not reducing, the extent of slum and vice in South African cities; on the other hand, it may add to the mounting racial tensions by accentuating the already marked contrasts in the residential conditions of white and non-white.

3rd November, 1953

A meeting was held in the Society's Room. Mr. L. W. Miller, Vice-President, presided.

The following were elected members of the Society:—Dr. W. Bryden, Mr. J. Palmer, Miss R. E. Royle, Miss J. C. Williams.

Dr. W. Bryden delivered an illustrated lecture entitled " A Trip to Ayers Rock, Central Australia ", of which the following is an abstract:—

> The purpose of a trip to Ayers Rock in Central Australia was outlined. The party included geologists, botanists, zoologists, and ethnologists and the object was to collect specimens from the area and to explore the district. Drawings in many of the caves were copied and photographed.
>
> The talk which was of a general rather than of a scientific nature was accompanied by a colour film.

1st December, 1953

A Special meeting was held in the Society's Room. The President, His Excellency the Governor (Sir Ronald Cross), presided.

The following was elected a member of the Society:—Mr. A. W. G. Powell.

Advantage was taken of the occasion to make a presentation to Dr. J. Pearson, who had filled the position of Hon. Secretary of the Society for 19 years. Sir Ronald Cross outlined Dr. Pearson's association with the Royal Society and the Museum and then called on Dr. W. L. Crowther and Mr. S. Angel (representing the Royal Society and The Friends of the Museum respectively) to speak. Sir Ronald Cross then presented Dr. Pearson with an inscribed travelling clock and a cheque for £111 as tokens of gratitude and esteem for his outstanding services.

Sir Ronald Cross mentioned that the present meeting was in the nature of a special meeting designed as the Royal Society's part in the Sesquicentenary Celebrations of the State. Accordingly it had been resolved to ask the State Archivist, Mr. R. Sharman, to address the meeting, Mr. Sharman gave an interesting address on " Immigration One Hundred Years Ago ", of which the following is an abstract:—

> This paper attempted to analyse the schemes by which migrants were assisted in settling in Van Diemen's Land in the period of Lieutenant-Governor Sir William Denison (Jan., 1847-Jan., 1855). The occupations, literacy, habits and expectations of those coming here as settlers in those years were examined, and the routine followed on board ship was studied by means of a description of the diet and other conditions of travel on board the *Panama*, which arrived here in April, 1853, and for whose passage some interesting particulars were available in official correspondence in the State Archives.
>
> Transportation was, up to 1853, the prime means of " inducing " new people to take up permanent or long-term residence in the Colony, and was especially significant in helping to establish colonial families in view of the practice, revived in 1847, of bringing out the wives and children of well-behaved transportees. This practice did little to adjust the disproportion of the sexes, however, and the Tasmanian Female Immigration Association was formed early in the period to encourage the introduction of unmarried young women, who were mostly drawn from the workhouses of England and Ireland.

The discovery of gold in California in 1849 and on the Mainland two years later resulted in a big stimulus to the production of foodstuffs and the breeding of livestock for export, bringing about conditions which temporarily called for the employment of more of the type of labour so easily gained by an immigration policy. However, the drift of breadwinners to the Mainland states in the last three years of the period reached such alarming proportions that Denison was prepared to go to any lengths to secure migrants.

The *Australasia*, the *Beulah* and the *Calcutta* arrived late in 1851, and these were the first of many ships which brought out migrants with their wives and families to found homsteads and develop farms in rural Tasmania. In many cases these people were proved to possess those qualities of enduring courage and initiative which admirably equipped them for the task of pioneering rural areas in the North West, North East and South East of Tasmania in the later years of the Nineteenth Century.

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The Algal Vegetation of Port Arthur, Tasmania

By

A. B. Cribb

Department of Botany, University of Queensland, formerly of Division of Fisheries, C.S.I.R.O.

with 10 plates and 2 text figures

Summary

An account is given of the algal vegetation of Port Arthur, Tasmania. The rocky shore is divided into three categories, "sheltered", "semi-exposed" and "exposed", each characterized by the presence in the lower littoral or sub-littoral fringe of a particular member of the Phaeophyta. These species are respectively *Hormosira banksii* (Turn.) Dcne. *Xiphophora billardieri* Mont. and *Sarcophycus potatorum* (Labill.) Kuetz.

Associations of *Zostera muelleri* Irmisch and of *Zostera tasmanica* Mart. characterize respectively the lower littoral and sub-littoral sand-mud flats in sheltered localities.

A comparison is made with the algal vegetation in other parts of Australia, the Subantarctic and Northern Hemisphere and the comparative paucity of the littoral vegetation in the Southern Hemisphere is noted.

I. Introduction and Description of the Area

Description of the area and environmental factors

Port Arthur, lat. 43·15° S., long. 147·9° E., opening on to the southern coast of the Tasman Peninsula in south-eastern Tasmania, is a comparatively narrow inlet averaging about one mile in width and extending northwards for approximately five miles, broken in places, particularly on the western shores, by several bays of varying size. The greatest depth recorded on Admiralty charts is 29 fathoms.

The area is a most interesting one from the point of view of algal ecology, offering as it does a considerable variety of algal habitats ranging from very exposed cliffs and surf swept rock platforms, the home of *Sarcophycus potatorum,* to extremely well protected bays where *Zostera* flourishes on gently shelving sand-mud flats. Rock surfaces of both dolerite and mudstone present widely varied slopes for algal colonization.

The exposed eastern shore of smooth dolerite is of varying steepness but for the most part descends precipitously into deep water. Above this shore the steep wind-swept slopes rising to Arthur's Peak and its subsidiary ridges are densely covered with a low scrub of *Leptospermum* sp., other small shrubs and somewhat stunted Eucalypts.

Passing north from Denman's Bay, known locally by the more picturesque name of Deadman's Bay, the rocky shore soon gives way to one of large dolerite boulders gradually decreasing in size towards Stinking Beach, a stretch of clean white fine sand, where after storms, large quantities of decaying algae justify the unusual name. The shore of dolerite boulders then extends round Evidence Point to the northern end of Long Bay, where it is replaced by a low sand-mud beach, sometimes with emergent rocks. Continuing along the western side of Long Bay, the bouldery shore is resumed to the north-west corner of Opossum Bay, broken only by clean sandy beaches at Stingray Bay and Stewarts Bay, by small outcrops of rocky shore at Garden Point and Frying Pan Point, and by a low mudstone outcrop in Stingray Bay.

Opossum Bay is bordered on the north-west by a sandy beach broken here and there towards the south by low outcrops of mudstone. Towards the south-west, with increasing shelter, the sand gains an increasing proportion of mud.

The north-west corner of Point Puer provides a small area of mudstone boulders and along the eastern shore of Point Puer stretch the distinctive laminated mudstone cliffs up to 100 feet high, from the base of which extend the horizontal or gently shelving mudstone platforms, (see Plates 5 and 9). After the wide sandy beach of Safety Cove which replaces the mudstone of Point Puer, there appears again the bouldery dolerite shore soon giving way to a rocky shore of variable slope which is finally replaced by the white sandy beach of Half Moon Bay.

II. Environmental Factors

1. TIDES. There are no tidal data available for Port Arthur but the behaviour of the tides seems to be similar to that described for Hobart by Guiler (1950) being of the semi-diurnal type in which a " high high " tide is followed respectively by a " low low ", " low high ", and " high low ". The extreme tidal range at Port Arthur appears to be approximately 6 feet.

2. SEA TEMPERATURE. Surface water temperatures were recorded by E. J. Wenck for the summer months of 1950-51 and 1951-52 and are given in Table I. The figures are the averages of weekly readings at 10 a.m., 12 noon and 3 p.m. The highest reading recorded was 18·5° C. during February, 1951.

TABLE I

Sea temperatures at Port Arthur

	Temperature (°C.)		Temperature (°C.)
October, 1950	13·8	October, 1951	14·0
November, 1950	14·7	November, 1951	14·5
December, 1950	15·6	December, 1951	14·5
January, 1951	17·3	January, 1952	16·3
February, 1951	17·3	February, 1952	17·8
March, 1951	16·9		

3. AIR TEMPERATURE. The station nearest to Port Arthur for which air temperature records are available is Cape Bruni, lat. 43° 29′ S. Here the highest monthly mean maximum temperature is 64·1° F, occurring during February. The lowest monthly mean minimum is 42·9°F, occurring during July.

4. RAINFALL. Figures made available by the Weather Bureau, Hobart, reveal that for the 30-year period 1911-1940 the average annual rainfall at Port Arthur was 40·42 inches and rain fell on an average of 197 days during the year. Table II shows the average monthly rainfall and the number of days in each month in which rain fell for the period 1911-1940.

TABLE II

Average monthly rainfall at Port Arthur for the period 1911-1940

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Rainfall (inches)	2·62	2·38	3·10	3·96	3·22	4·54	3·78	3·68	2·88	3·75	3·04	3·47
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Days in which rain fell	13	11	15	16	18	19	19	18	18	18	16	15

5. WINDS. The prevailing wind over southern Tasmania is between north and north-west, with frequent south-easterlies in summer and early autumn. South to south-west winds are fewer and usually of lower velocity than the north and north-west winds.

6. SALINITY. No figures are available for salinity, but as no large fresh-water streams enter the area the variation is probably slight.

7. ILLUMINATION. No measurements of light penetration at various depths have been made but the water appears very clear and the amount of sediment introduced by the few very small streams probably has a negligible effect on light penetration.

III. TERMINOLOGY

The meanings of terms applied to the various horizontal divisions of the shore are those advocated by Womersley and Edmonds (1952). The littoral zone is regarded as that part of the shore between extreme high water mark of spring tides and mean low water mark of neap tides. This zone may be divided into upper, mid-, and lower littoral. Above the littoral is the supra-littoral zone and below is the sub-littoral fringe occupying the range between mean low water mark of neap tides and extreme low water mark of spring tides. Below this is the upper sub-littoral zone.

Following Cotton (1912), the algal associations are assigned to either the " rocky shore formation " or " sand and sand-mud formation ", the other formations recognised by Cotton at Clare Island being unrepresented at Port Arthur.

It has been found convenient to divide the rocky shores on the basis of degree of exposure, into three groups, each characterized by particular associations, mainly of the larger brown algae.

These three categories have been designated:—

Sheltered
Semi-exposed
Exposed

These terms are entirely relative and are designed only to distinguish between the degrees of exposure occurring within Port Arthur. Of course, the characteristic vegetation of each category grades gradually or suddenly into that of the next and many points on the shore can be found where the vegetation is of an intermediate nature. Also, along a comparatively short length of shore two or occasionally three of the vegetation types may be found as local variations in topography modify the degree of exposure, the seaward face of a boulder perhaps falling into one category while the landward face fits more easily into another.

However, on the whole, this division of the shore, made on the basis of degree of exposure, has been found to be convenient for Port Arthur, and there is generally little doubt as to the category into which a stretch of shore should be placed.

In this paper the abbreviations "E.H.W.S." and "E.L.W.S." are used for "extreme high water mark of spring tides" and "extreme low water mark of spring tides" respectively.

IV. Vegetation of the Shore

A. Rocky Shore Formation

1. *Sheltered Shore*

Belonging to this sheltered category are the shores of Opossum Bay, Stewart's Bay (with the exception of parts of its northern and south-eastern shores), most of Long Bay, and Stingray Bay.

With the exception of the mudstone pavements in western and southern Opossum Bay, most of the shore in these areas is of dolerite boulders of varying size interrupted in a few places by sand or sand-mud beaches.

In nearly all places the Eucalypt forest approaches close to the shore and is associated with a shrubby under-story which includes *Bedfordia linearis* DC., *Exocarpus cupressiformis* Lab., *Goodenia ovata* Sm., *Ozothamnus gunnii* (Hook. f.), F. Muell. ex Benth., O. sp., and other species, together with a ground cover which commonly includes *Lomandra* sp. (cutting grass) and *Stipa teretifolia* Stend.

(*a*) *Supra-littoral*

The encrusting lichens of the supra-littoral are a conspicuous feature of the rocky shore at Port Arthur, as elsewhere in Tasmania, and though by no means restricted to the areas designated in this account as "sheltered" they may conveniently be described here. They show a fairly constant and distinct zonation which, however, may be considerably modified by change in aspect.

(1) *Parmelia* association (grey-green Lichen association).

Highest on the shore is the grey-green lichen association consisting of *Parmelia perforata* (Wulf.) Ach., *P. conspersa* (Ehrl.) Ach. and other species rarely with patches of the dark-green more gelatinous thalli of *Collema* sp., and often mingling in its upper part with mosses such as *Ptychomitrium mittenii* Jaeg. and occasional plants of *Arthrocnemum australasicum* Moq. or tufts of *Stipa teretifolia* the two Phanerogams which venture farthest down the rocky shore and may be partly submerged at E.H.W.S. The lichen species of this association do not appear to be restricted to the shore and possibly reach a satisfactory development here mainly because freed from the restricting shade of the Eucalypt forest.

(2) *Ochrolichina* association (white lichen association).

The *Parmelias* are followed by the striking association of white lichens. This consists mainly of *Ochrolichina parella* (Linn.) Massal, with white or pale apothecia, together with some *Patellaria rimosa* M. Arg. with its contrasting black apothecia. Both form a hard, close, white or silvery grey encrustation and together may almost completely cover the substrate giving the rocks the appearance of being heavily whitewashed, and standing out quite distinctly from a distance of a mile or more (see Plate 1).

In the most sheltered localities this band may be only 2 feet 6 inches in height with its sharply marked lower limit slightly below the level of E.H.W.S., but it responds readily to change in exposure as is evidenced by the marked elevation and extension of the band with increasing spray. In exposed positions the association may have a vertical extent of 20 feet and its lower limit be elevated 15 feet or more above the E.H.W.S. in calm weather. When observing from a distance a shore along which the degree of exposure is changing, this gradually narrowing bright white band can be seen to drop lower and lower on the shore as degree of exposure decreases.

The upper part of the band mingles with the *Parmelia* association, and there is some evidence that in places, competition with this association may prevent the white association's attaining its full range.

The association shows a striking preference for southern exposures and on a shore with a northerly aspect is almost or entirely absent.

(*b*) *Upper littoral*

(3) *Candelariella* association (orange-yellow lichen association).

Overlapping the lower margin of the white lichen association are colonies of orange-yellow lichens which comprise the next downshore band. This association consists mainly of *Candelariella vitellina* (Ehrh.) Muell. Arg. and *Teloschistes parietinus* (L.) Norm. generally with the former predominating but sometimes with the *Teloschistes* locally dominant. A few flecks of the orange-red *Gasparinnia murorum* (Hoffm.) Dodge & Baker may occasionally appear, but it is a relatively unimportant species at Port Arthur. Some small light or dark-grey encrusting species also occur in the association but being similar in colour to the rock surface they are inconspicuous.

Though the highly coloured constituent species may in places form an almost complete cover within the band, such dense covers tend to be local in occurrence, and the association at Port Arthur never reaches the development found in some other parts of Tasmania, as for instance at Low Head, Bicheno, and Southport.

As in the case of *Ochrolichina* the position and extent of the band which the association forms alter with changing exposure, and though in sheltered localities it occupies a band in the upper littoral approximately 1 foot in vertical extent, when subject to exposed conditions the range is considerably increased and the lower limit appears several feet above E.H.W.M. in calm weather.

In contrast to the *Ochrolichina* and *Patellaria*, the constituent species of the orange-yellow association seems to show some preference for a northerly aspect. This preference for the north is not so marked or exclusive as that shown by the *Ochrolichina* association for the south, and though in places all the lichen associations may be seen distinctly banded in downshore succession, in general, at any point where either the white or orange-yellow association approaches optimum development the banding is likely to be less marked than at positions where neither association finds conditions entirely favourable.

(4) *Verrucaria* association (black lichen association).

The orange-yellow association is succeeded by a foot-wide band of *Verrucaria microsporoides* Nyl. often forming a complete hard black coating over the rock surface, though since the rock itself is often of a dark colour this association from a distance is not so conspicuous as the white and orange-yellow associations above it. The upper limit of the *Verrucaria* association like the lower limit of the *Ochrolichina* association is often sharply marked and it is within the clearly defined band of shore, often 6-9 inches in height, between these two association, that the orange-yellow species find their maximum development, though there may be some mingling with the bounding associations, particularly with the *Verrucaria* below.

The *Verrucaria* does not seem to respond very markedly to change in aspect, but it favours the more protected areas and is generally not found on exposed shores.

(5) *Lichina* association.

Following the *Verrucaria* is the lowest lichen band constituted by the Pyrenolichen *Lichina confinis* (Muell.) Ag. This remarkable species, submerged regularly at high tide, extends downwards from the lower limit of the *Verrucaria* for a distance of about one foot, forming firm cartilaginous colonies, rounded, lobed or irregular, generally one quarter to two inches in diameter and not more than one quarter inch high. Older colonies sometimes decay at the centre leaving rather characteristic black rings, and more rarely a colony may be in the form of two concentric rings. (see Plate 2.) When dry they are quite black and rather brittle, but after immersion change to a dull greenblack and become more fleshy. The *Lichina* often forms quite a distinct band, but it is an association of scattered colonies and only in localised areas where very

exceptional development has taken place is there anything even approaching a complete cover. Generally, though not invariably, the colonies shelter no animals. The association may at times tend to be intermittent and sometimes rocks within the band are quite uncolonised, the reasons for these fluctuations often being not readily apparent. There seems to be a slight preference for southern exposure, but the species is certainly not confined to this aspect.

The common littorinid, *Melaraphe unifasciata* (Gray), generally finds its lower limit among the *Lichina*, though its upper level is very variable depending mainly on degree of shade and amount of spray. In very sheltered localities it usually does not extend higher than the lower limit of the *Ochrolichina* association.

(6) *Bostrychia* association.

The first band of macroscopic algae to appear on the shore is formed by the *Bostrychia* association which thrives only where considerable shade and shelter are available. It may sometimes appear at the upper *Verrucaria* limit, but finds its optimum development below this association, occupying roughly the same vertical range as *Lichina*. Since it prefers the shaded boulder faces and crevices it is generally found somewhat to the rear of *Lichina* and the two rarely intermingle. Ideal conditions occur along the bouldery north-eastern shore of Long Bay, and here the association reaches maximum development forming a thick woolly felt on the shaded surfaces. Where overhanging rock ledges provide particularly moist and shaded conditions, the *Bostrychia* may hang in matted untidy festoons of densely tangled filaments. In very shaded situations the colour is almost black, and though typically it is a dark dull purple, the margins of more exposed colonies, where conditions presumably are far from optimum, sometimes appear a yellowish-brown. This association is composed of a mixture of two species, *Bostrychia mixta* Hook. and Harv. and *Bostrychia simpliciuscula* Harv., generally with the former predominating. Glistening patches of *Caloglossa leprieurii* (Mont.) J. Ag. sometimes occur on the mat of *Bostrychia*, small colonies of *Enteromorpha* are found occasionally, and in particularly shaded situations a bright green felt of *Rhizoclonium riparium* (Roth) Harv. or a blue-green scum of *Hydrocoleum glutinosum* (Ag.) Gom. may overlie the colonies.

Frequently associated with the *Bostrychia* is *Hildenbrandtia* sp. forming a very thin dull blood-red crust over the rock surface. The position and extent of this encrustation is dependent upon the presence of the deep very shaded crevices found along a shore of large boulders and in such a position it may appear at about the upper limit of *Verrucaria* and extend downwards for perhaps two feet to positions where the light intensity may be extremely low. *Bostrychia* colonies are frequently developed over the better illuminated parts of the crust which, however, is able to penetrate well beyond the limit of shade tolerance of *Bostrychia*.

(c) Mid-littoral

The strip of shore, generally 12 to 18 inches in vertical extent, between the lower limit of *Lichina* and upper limit of *Galeolaria caespitosa* (Lam.) is often floristically very bare, and though damp chinks and crevices sometimes facilitate algal invasion from the associations below,

it is predominantly an animal zone dominated by limpets and often carrying barnacles, mussels and gastropods. But within this band there may occur in various localities, several well marked algal communities.

Three limpet species are almost universally present at Port Arthur though other species also occur. The uppermost species is *Siphonaria zonata* (Teneson-Woods), a small species, dull white and indistinctly zoned with bands of blue-grey. The individuals occupy a narrow band, perhaps three inches in vertical extent at about the lower *Lichina* limit, and though fairly constantly present are nearly always sparse and inconspicuous.

The small, ribbed *Siphonaria diemenensis* (Quoy & Gaimard) which extends downwards from just within the region of *S. zonata* is by far the most common limpet on the shore and reaches the *Galeolaria* band still in considerable numbers. When this species occurs on the fallen tree trunks which lie here and there partly submerged along very sheltered shores, the limpet home is marked by a green ring-shaped stain caused by some microscopic green or blue green alga. Individuals on such wooden substrata are particularly likely to carry colonies of a species of *Hildenbrandtia* apparently different from the species occurring on shaded rocks in the upper littoral. These colonies fleck or sometimes completely envelop the shell with a dull red crust.

The third species of limpet is a large *Cellana* sp., the number of individuals quite small compared with *Siphonaria diemenensis,* but their dull white shells up to one and one-half inches in basal diameter standing out very clearly where they do occur. They may be found anywhere between the associations of *Lichina* and *Galeolaria,* but generally prefer positions nearer the *Galeolaria,* though at high tide their migration may take them within the *Lichina association.* The shells may sometimes carry colonies of various algae such as *Ulva lactuca* L., *Ceramium paniculatum* Okamura or *Gelidium pusillum* (Stackh.) Le Jol. and where *Bostrychia* is common may bear a dense spongy felt of *B. mixta* which they may carry below the normal limit of this species.

The uppermost inhabitants of the mid-littoral are usually the small barnacle *Elminius* sp. and the conical gastropod *Bembicium melanostoma* (Gmelin) both of which find only the lower part of their range here, and extend well into and sometimes above the *Lichina* association, the *Bembicium* generally extending a little above and below the *Elminius.*

The barnacle *Chamaesipho columna* (Spengler), typically an inhabitant of the exposed shores, may sometimes occur below the *Elminius,* but if present at all, is usually poorly developed.

A barnacle far more constantly present though not usually in any great numbers, is *Tetraclita purpurascens* (Wood), a large low species with a light-grey rugose shell. The presence of this species is dependent upon a certain amount of shade and it is usually found in crevices, on the shaded sides of boulders, or under rock ledges, so that although it may be quite common it is sometimes not so readily noticed as other species. Where its conditions of shade and shelter are fulfilled it may occur anywhere within this band, generally with its greatest development 6-9 inches above the *Galeolaria.* The mudstone pavements being particularly bare of such localised shady habits are almost devoid of this species.

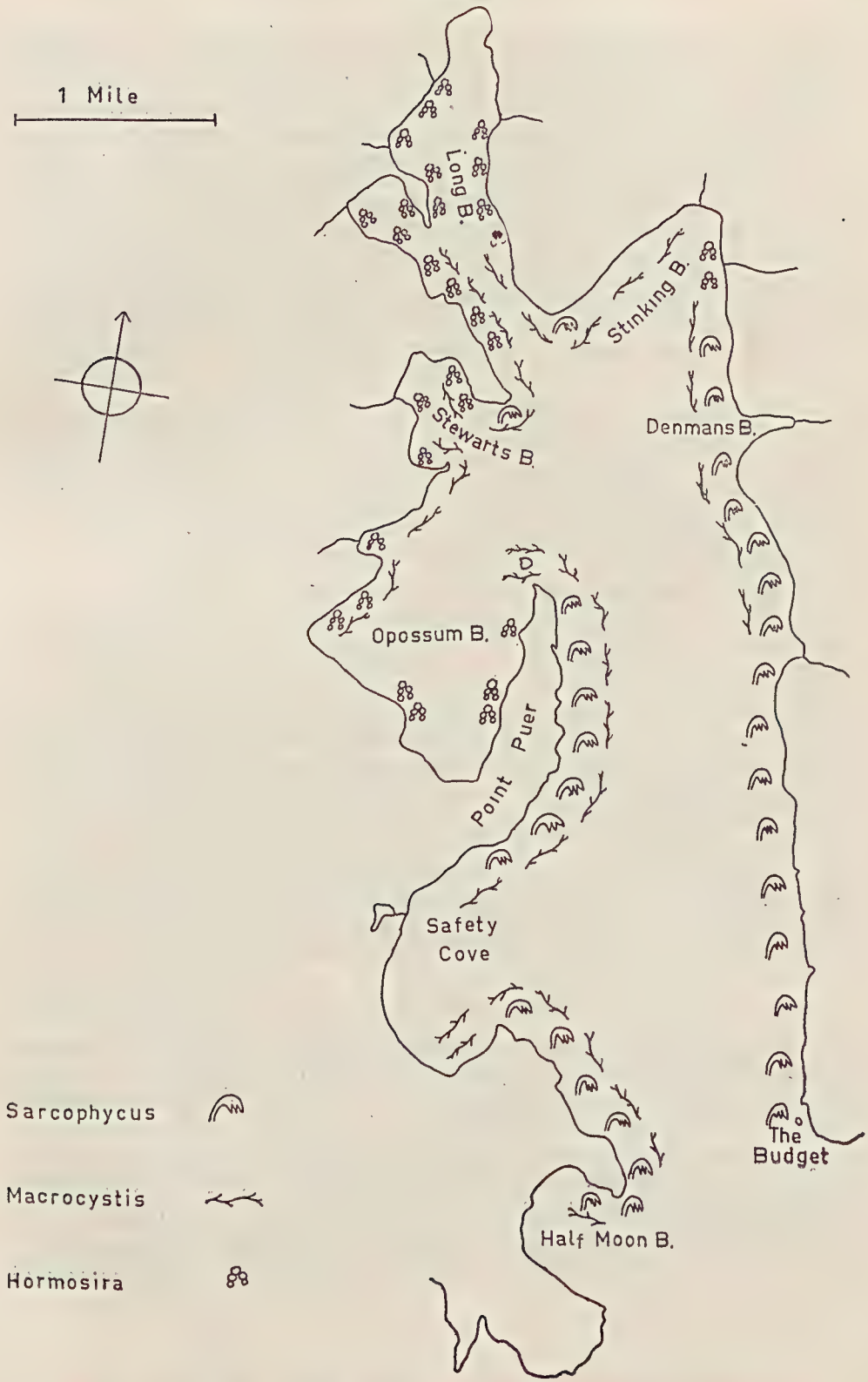

FIG. 1.—Map of Port Arthur showing the main distribution of *Sarcophycus Macrocystis* and *Hormosira*.

The small mussel *Brachyodontes rostratus* (Dunker) may also be important in the animal band. It appears to be incapable of colonising directly a smooth rock surface and on a bouldery dolerite shore the colonies are initiated in the crevices between boulders and extend outwards over the smooth rock surface by marginal increase, frequently accumulating sand and shell grit between the densely packed purple-black shells. On the mudstone pavements, the cracks and fissures at suitable levels are generally marked by black lines of these densely crowded mussels, and pock marks and small depressions in the rock surface each bears a black cluster. Where a change from the pockmarked rock to smooth surface occurs within the *Brachyodontes* region, the sudden disappearance of the species is most striking. Where the necessary cracks or pitted surfaces are available its range may extend from within the lower *Lichina* to within the upper *Galeolaria,* though the best development is generally reached a little above the upper limit of *Galeolaria.*

Two algae are commonly, though not invariably, associated with the *Brachyodontes.* During winter, *Callithamnion* sp. forms short red plumose tufts up to one inch high and is not, as a rule, found on adjacent rock surfaces. The other species is *Gelidium pusillum* its branches densely entangled between the shells and sometimes forming a firm spongy tuft over the surface of the *Brachyodontes* colonies. Both species occur mainly in the lower part of the *Brachyodontes* range.

At times an algal species commonly present on this strip of shore is the blue-green *Rivularia australis* Harv. Its soft rubbery thalli form irregularly rounded inflated hollow colonies often about one half inch in diameter, generally bottle green after recent submersion, but sometimes drying to a black crust when exposed for a considerable time. The colonies are often rather widely scattered so that the species may not form a conspicuous band. Though occasionally it has been found growing on colonies of *Lichina* the best development is found in the lower part of the band nearer the *Galeolaria.* The species is seasonal in its occurrence being mainly a summer form, found only very rarely during winter months. The young colonies generally start to appear about October.

During winter, *Porphyra umbilicalis* (L.) J. Ag. may occur here and there within this band, generally as isolated individuals or small communities, but along these shores it never forms the dense association found on some of the more exposed shores of Port Arthur.

Scytosiphon lomentarius (Lyngb.) J. Ag. also mainly a winter form, is, like *Porphyra,* very sporadic in its occurrence along these shores.

Some species seem to be mainly restricted to positions of extreme shelter often where the rocks emerge from a sandy-muddy shore. Among these are *Chordaria dictyosiphon* (Harv.) Kuetz., *Hildenbrandtia* sp., *Enteromorpha* sp. and *Monostroma* sp.

Scattered clumps of the *Chordaria* are found on rocks and particularly on logs in the lower part of this band and may extend downwards into the *Hormosira* association.

The *Hildenbrandtia* forms small rounded or oval red-brown crusts often not more than one quarter or one half inch in diameter, and

occasionally in extreme cases may occur so thickly that the confluent colonies completely cover the small boulders. It differs from the species found in the upper littoral in its thicker crust and usually definite colonies.

Sometimes the rock surfaces in these exceptionally sheltered positions develop a dark slippery coating of *Calothrix* sp. and on this may occur occasional colonies of *Enteromorpha* sp. and a few delicate pale-green plants of *Monostroma* sp., generally not more than two inches in length. *Enteromorpha* does not usually form a distinct band in any part of the shore though a bright-green mat may mark the position of fresh-water seepage on the shore. In one place, shallow upper littoral pools frequently polluted by the cleaning of fish in the vicinity carried a dense growth of *Enteromorpha intestinalis* (L.) Link during winter. The hot weather often proves fatal to the *Enteromorpha* communities and the plants quickly become bleached during summer.

Most of these species seem able to extend the upper limit of their range when growing on fallen tree trunks, and *Enteromorpha* often appears quite densely on this substratum though absent on adjacent rock surfaces, while *Bostrychia mixta* is often able to survive here without the usually necessary degree of shade. These logs sometimes carry a variety of blue-green algae which are generally absent on the rocky shore, and among these may be mentioned *Calothrix pilosa* Harv. forming a dark olive-green pilose-velvety stratum generally in the upper littoral region.

(7) *Galeolaria-Gelidium* association.

One of the most distinctive associations on the shore is provided by the *Galeolaria caespitosa-Gelidium pusillum* association generally with its fairly sharply defined upper margin. (see Plate 3.) The *Galeolaria* does not reach the excessive development found in the Sydney district of New South Wales, where the mass may be several inches thick, and at Port Arthur the bright white layer of interwined calcareous tubes is seldom more than one tube in depth. Vertically the tubes may extend for about 18 inches, but this range is frequently not realised because of the heavy competition with algae in the lower part of the association, so that the vertical extent of the band is more often in the vicinity of ten inches. The upper part of the association can be regarded as being in the mid-littoral, but the lower part of the *Galeolaria* penetrates well into the lower littoral.

Nearly always associated with the *Galeolaria* is the small alga *Gelidium pusillum*, the decumbent dark red-black richly branched cartilaginous thalli contrasting with the white of the intricate mass of tubes which provided so suitable a substrate for this creeping species. The *Gelidium* prefers the upper part of the *Galeolaria* range and occurs only to a very limited extent on adjacent rock surfaces, though, as already mentioned, its range may be extended above the *Galeolaria* in the presence of *Brachyodontes*. Though generally intimately mixed with and difficult to separate from its substrate, it may, when shelter is extreme, occasionally form rounded cushion-like clumps which can be removed from the substrate with comparative ease.

Occasionally a yellow-green sponge *Hymeniacidon perlevis* (Montagu) is found growing over the *Galeolaria* particularly in shaded localities and in the rare cases where the tubes do locally form a layer perhaps an inch thick, the barnacle *Ibla quadrivalvis* Cuvier may be found imbedded in the mass.

The congregation at low tide of individuals of *Siphonaria diemenensis* immediately above a sharp upper limit of a dense band of *Galeolaria* suggests that the uneven surface of the tube worms may hinder the further downward migration of these small limpets.

(8) *Ulva* association.

An association which is to some extent seasonal in its occurrence is constituted by *Ulva lactuca*, sometimes with other Chlorophycean genera, which generally forms the first conspicuous band of macroscopic algae on the shore. In some places old plants may occur infrequently throughout the mid-littoral but maximum development is generally reached just above and below the upper limit of *Galeolaria* though plants frequently extend in considerable numbers into the *Hormosira* association and sometimes very sparsely into the upper sub-littoral. There is a decided preference for shores of small boulders and here the bright-green sheets plastering the rocks at low tide may form a complete cover for a vertical distance of 9-12 inches. On rocky shores the preference is for gently sloping surfaces rather than vertical faces.

By November there is generally some attenuation of the association, particularly in the upper parts, and during the hotter months it is frequently represented only by scattered individuals in the *Hormosira* association.

Plants are sometimes heavily parasitised by *Myrionema strangulans* Grev. flecking the thalli with numerous rounded brown spots 2-5 mm. in diameter.

Associated with the *Ulva* in some places are a few plants of *Cladophora flexuosa* Harv. forming rather dense basal clumps from which may be emitted a tuft of long sparsely branched filaments. The species has a narrow vertical range, often no more than 3 inches, its exact position depending upon degree of exposure but usually occurring just above the *Galeolaria*, and marking the upper limit of the dense band of *Ulva* where this is present.

Another species sometimes found in the association though more usually found at lower levels, is *Bryopsis australis* Sonder, the soft heavy dark-green clumps scattered here and there amongst the *Ulva* on bouldery shores, while a species of *Ralfsia* sometimes forms chocolate-brown crusts over small boulders and stones particularly where there is some localised shading from adjacent boulders.

(d) Lower littoral

(9) *Hormosira* association.

The presence of a yellow-brown band of *Hormosira banksii* is a conspicuous feature of most rocky and bouldery shores in sheltered localities at Port Arthur (see Plates 3 and 4) and the distribution of this

species is shown in Figure 1. The position and sharpness of the association's upper limit varies with the habitat being most distinct on rocky shores with a slope of 30°-45° where it is bounded above by a well marked white band of *Galeolaria*. On vertical faces the cover, generally developed on the calcareous tubes, is sparse and the irregular upper boundary 3-6 inches below upper *Galeolaria*. Where the slope is very gentle the association ascends a little higher, the uppermost plants taking advantage of any small chinks or pock marks in the rock surface. The extreme vertical range of the association is in the vicinity of 18 inches.

Being in the main bouldery and fairly steep, the dolerite shore carries, for the most part, only a narrow band of *Hormosira*, and it is on the mudstone pavements of Opossum Bay that the association is seen at its best. Here it spreads out horizontally, often for several yards, densely covering the platform with the lax chains of fleshy yellow-brown beads.

In such positions the dense cover may almost completely exclude *Galeolaria* which on vertical faces extends well into the association.

Frequently associated with the *Hormosira* is an understory of several species chief of which is *Corallina pilulifera* Post. and Rupr. This species sometimes with *Jania* sp. forms a low dense coralline carpet providing an ideal substrate for the other small constituents of the association. *Corallina*, when associated with *Hormosira*, ascends considerably higher than on bare rock surfaces probably because the sheltering *Hormosira* prevents excessive desiccation. In the mid and lower parts of the association *Lithothamnion incisum* Fosl. sometimes consolidates the carpet with its rounded encrusting plates. *Corallina* is not invariably present with *Hormosira*, and its intolerance of muddy conditions forces it in some places to leave the association.

Apart from the *Corallina*, the understory usually is not dense, and though several species have been collected mainly in the mid and lower parts of the association, most of them are somewhat sporadic in occurrence. Species which do appear fairly regularly are *Laurencia botryoides* (Turn.) Gail. and a small procumbent species of *Gigartina*. Where *Hormosira* is sparse, gelatinous light-brown colonies of *Leathesia difformis* (L.) Aresch. and of the inflated *Colpomenia sinuosa* (Roth) Derbes and Solier have been found on occasions particularly in the more exposed localities.

A species entering the association in some places on the bouldery shore though seldom on the platforms is *Codium fragile* (Suringar) Heriot. Within the "Sheltered" localities it appears to enjoy the more exposed positions, and in extremely sheltered localities, if present at all, is poorly developed and covered with a muddy sediment. Typically, the robust dark-green dichotomously branched plants, generally densely tomentose, are fairly scattered, but just occasionally in a very limited area may form an almost complete cover. The plants commonly carry an epiphytic growth species of *Ceramium* including *C. paniculatum* which sometimes forms a dense red fringe almost completely obscuring the frond. Less frequently *Acrochaetium codicola* Boergs. may form a similar, but shorter and finer fringe.

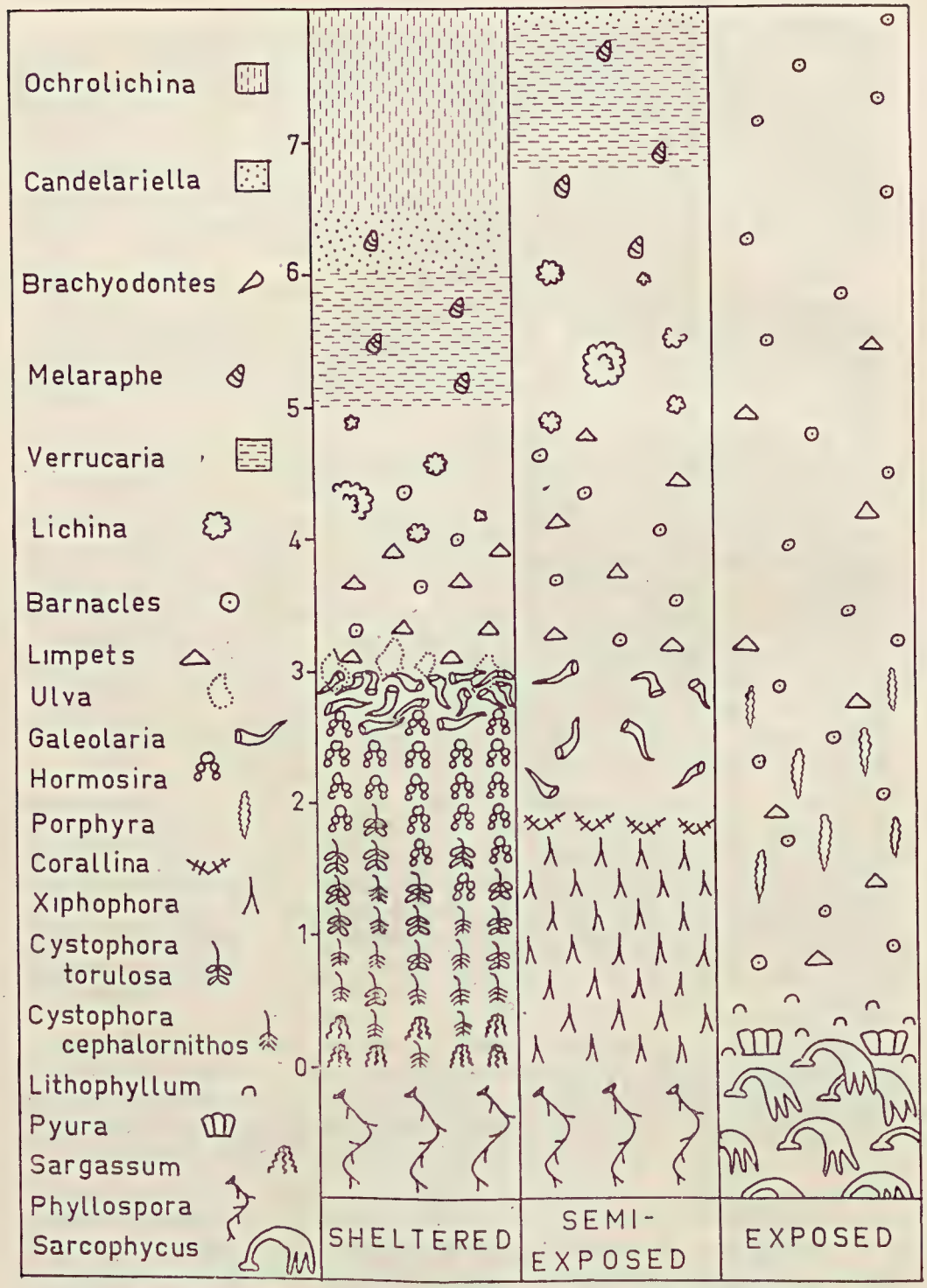

FIG. 2.—A generalized representation of the zonation of the more prominent floral and faunal bands on rocky shores of moderate slope. Zero is the approximate position of E.L.W.S. and the measurements are given in feet.

As already mentioned, *Ulva lactuca* sometimes joins the association and where a vigorous growth of *Codium* has also developed, the *Hormosira* may have to share its dominant position with these two species.

The form of *Hormosira* shows some variation depending mainly upon the degree of exposure to which the plants are subjected, those from the most sheltered positions being densely branched with large soft pale-yellow spherical internodes occasionally up to one inch in diameter, while in more exposed positions the plants are more sparingly branched and the smaller, firmer and more oval or cylindrical internodes may take on a darker colour. *Hormosira* does not seem to be intolerant of muddy conditions and at Boomer marsh, some miles from Port Arthur, large areas are covered with healthy plants attached to mussels half buried in the soft mud.

Plants of the parasitic *Notheia anomala* Bail. and Harv. are sometimes found issuing from the conceptacles of *Hormosira*, and at times various epiphytes are present. The blue-green *Symploca hydnoides* Kuetz. may form gelatinous olive-green collars at the nodes, *Polysiphonia fuscescens* Harv. appears epiphytically in somewhat muddy localities, and on various occasions *Ulva lactuca*, *Punctaria plantaginea* (Roth.) Grev., *Griffithsia monilis* Harv., *Ceramium paniculatum* and *Ectocarpus mitchellae* Harv. have all been found on *Hormosira*. In general, however, the plants do not carry a heavy burden of epiphytes.

Mytilus planulatus (Lam.) is by no means restricted to the "Sheltered" areas and its main requisite seems to be a horizontal or gently sloping surface at a suitable level. Since the bouldery dolerite shore provides this only occasionally in very localised positions, the occurrence of *Mytilus* on this type of shore is sporadic, and it is generally more common on the mudstone platforms where it occupies roughly the same vertical range as the *Hormosira* among which it often occurs when the latter is not too dense. But neither its upper nor lower limit is sharply defined, and it may extend in both directions for a short distance beyond the *Hormosira* (see Plate 4). As a rule, dense mussel beds are not found, the species occurring only as scattered individuals or small groups. Its vigorous development on wharf piles seems at variance with the preference shown on rocky shores for the more nearly horizontal surfaces, and in Long Bay the wooden piles of an old wharf carry a dense band of mussels sometimes with a vertical extent of 3 feet. In this position the upper shells often support a bright-green growth of *Enteromorpha* sp. which is replaced further down by *Ulva*. In the lowest part of the *Mytilus* range there is some mingling with sponges before *Ecklonia radiata* (Ag.) J. Ag. takes over in the sub-littoral. *Hormosira* is absent from these piles and is seldom found attached to wooden surfaces.

The *Hormosira* is gradually replaced downwards by a series of associations each passing insensibly into the one above or below, but each in turn reaching maximum development about the middle of its range where for a short distance the dominant may occur as an almost pure stand (see Plate 4).

Though general appearance of a species is often no reliable indication of drought resistance the four species of this series do show a gradation in fleshiness from the stout water-filled internodes of the upper-most *Hormosira* to the somewhat membranous blades of the lowermost *Sargassum,* and this diminution in fleshiness could reasonably be correlated with the increasing intolerance to exposure in the plants of this downshore succession.

(10) *Cystophora torulosa* association.

The first of these species to compete with the *Hormosira* is the fleshy bright-yellow *Cystophora torulosa* (R. Br.) J. Ag. The uppermost plants appear about 9 inches below the upper limit of the *Hormosira* association and gradually increase in numbers downwards till at a point approximately 9-12 inches below the upper *Hormosira* it assumes a position of dominance which it retains for perhaps 5-6 inches.

In common with *Hormosira,* it may overlie the same Coralline carpet with the scattered plants of *Laurencia* and *Gigartina. Corallina cuvieri* Lamx. which is rare among the *Hormosira* becomes more common here.

Though frequent on the bouldery dolerite shore, this *Cystophora* is, like *Hormosira,* best developed on the platforms when the association spreads out horizontally displaying the zonation of the species to much better advantage.

The luxuriance of the association varies considerably within the "Sheltered" category and with increasing exposure it is usually the first of these four species to disappear.

(e) *Sub-littoral fringe*

(11) *Cystophora cephalornithos* association.

Cystophora cephalornithos (Labill.) J. Ag. is confined to the lowermost part of the littoral zone and to the sub-littoral fringe. It first appears among the lowermost plants of the *Hormosira* association gradually increasing in numbers till it ousts *Cystophora torulosa* from its dominant position and forms a band of variable purity in the sub-littoral fringe. The simple or sparingly branched stems, generally 1-2 feet long, are clothed towards the apex with densely placed slender ramuli, but the lower part of the rachis is quite denuded and, if not encased by a bright pink encrusting coralline, usually carries a number of small epiphytes, including *Sphacelaria biradiata* Askenasy.

(12) *Sargassum laevigatum* association.

The final algal association before the sub-littoral proper is constituted by the densely bushy plants of *Sargassum laevigatum* J. Ag. These occur in a very narrow band at a slightly lower level than the main band of *Cystophora cephalornithos,* but in company with this species can be regarded as occupying the sub-littoral fringe. Its preference is for positions slightly more exposed than those favoured by *Cystophora torulosa,* and though the two are often found on the same shore, in localities where it shows optimum development the *Hormosira* may pass almost directly into the *Cystophora cephalormithos* and *Sargassum* associations without an intervening band of *Cystophora torulosa.* In such positions other

species may enter the sub-littoral fringe though usually in small numbers. *Cystophora spartioides* (Turn.) J. Ag. and *Sargassum muriculatum* J. Ag. are two of the larger species found sporadically while stunted plants of smaller species such as *Zonaria subarticulata* (Lamx.) Papenfuss and *Cladostephus verticillatus* (Lightf.) Ag. may occur quite commonly though typically both belong to the sub-littoral. The *Cladostephus* seems to show a preference for positions where sand overlies the rocks.

The coralline understory constituted by *Corallina pilulifera* and *Jania fastigiata* Harv. may descend into the *Sargassum* association but this usually marks its lower limit. However, *Corallina curvieri* which first appears in the lowermost part of the littoral and in the sub-littoral fringe may extend into the sub-littoral though it is not a common species at Port Arthur.

(*f*) *Sub-littoral*

(13) *Phyllospora* association.

An extensive and well developed sub-littoral vegetation is present on most rock surfaces at Port Arthur, the uppermost association of this region generally being formed by *Phyllospora comosa* (Labill.) C. Ag. The strap shaped stems often 6-9 feet long closely beset with coarsely toothed leaf-like processes are buoyed up by numerous large oval vesicles and form a dense band often 6-12 feet wide clearly marked by the numerous sharply pointed " leaves " projecting above the surface of water. The uppermost holdfasts may occasionally be just exposed at E.L.W.S. but the association here is definitely one of the sub-littoral and not the sub-littoral fringe. In these " sheltered " localities the plants usually extend no deeper than a point about 6 feet below E.L.W.S.

This dark semi-floating mass is often so dense that the light intensity beneath it must be very considerably reduced, and this is borne out by the fact that the understory in these positions is often very sparse, the main vegetation consisting of the bright pink encrusting corallines which here are exceptionally well developed and cover a large proportion of the rock surface.

A few epiphytes may be present chief among which is generally *Polysiphona cancellata* Harv., and the leaves may sometimes carry a fine, light-pink granular coating of *Melobesia* (?).

(14) *Cystophora retroflexa* association.

The heavy development of *Cystophora retroflexa* (Labill.) J. Ag. which often occurs in a band just below the *Phyllospora* seems to warrant the rank of association. Densely branched plants of a pale straw colour when fresh are, like the *Phyllospora,* buoyed up by numerous rounded or oval vessicles about the size of a pea, and the association is marked by the numerous slender terete pinnules protruding above the surface of the water. Though the band is dense, it has not the same light excluding properties as the *Phyllospora* association and consequently does not noticeably reduce the density of the understory.

(15) *Macrocystis* association.

The third of these semi-floating associations is constituted by *Macrocystis pyrifera* (L.) Ag. Certainly it does not show maximum development in these very sheltered localities but nevertheless where a rocky bottom is present it does frequently form a fringing bed of variable density and width. There may be some mingling with the *Phyllospora* and *Cystophora retroflexa* but in the main the beds are found beyond these bands. In calm weather portions of the blades project above the surface in graceful arcs marking the extent of the bed, a beautiful sight with the sun shining through the projecting golden laminae. Like the *Phyllospora* a dense cover may considerably reduce the light intensity on the floor below and the understory suffers a corresponding attenuation.

The epiphytes of *Macrocystis* show their best development in these very sheltered localities and the blades sometimes carry numerous plants of *Polysiphonia frutex* Harv. Other epiphytes occur sparingly particularly on old and decaying blades, and include *Ectocarpus confervoides* (Roth) Le Jol., *Ceramium* sp. and *Polysiphonia* sp. On some plants the small parasitic *Myrionema densum* Skottsberg forms numerous rounded or oval brown spots 0·5-2 mm., in diameter, over blades, bladders and stipes.

(16) *Ecklonia* association.

Covering a great deal of the bouldery floor in the sub-littoral is a fairly dense vegetation of variable composition and density, dominated by members of the *Phaeophyta.* The most important of these is usually *Ecklonia radiata* with its broad pinnatifid lamina 1-2 feet in diameter borne on a tough cylindrical stipe the whole plant generally 2-4 feet in length. This species may occur in the sub-littoral anywhere from E.L.W.S. and the uppermost plants are occasionally just uncovered by extremely low tides. Generally, however, competition with *Phyllospora* reduces its numbers in the upper part of the sub-littoral and it is beyond the *Phyllospora* association that more optimum development is exhibited. Sponges, bryozoans and other animals are frequently sheltered by the much branched holdfast, and the lamina, particularly in older plants may carry a few epiphytes though it is usually not heavily burdened.

The sub-littoral has not been studied in detail, but, observed from a boat in calm weather, the *Ecklonia* appears to be accompanied by a rich flora of sub-littoral species, most prominent among which are members of the *Phaeophyta.* These larger forms no doubt shelter a variety of smaller Rhodophytes which are sometimes cast up after rough weather. Of the accompanying larger Phaeophycean species perhaps the most common is *Zonaria subarticulata,* the densely crowded flabellata fronds forming regularly hemispherical cushion like masses on boulders among the *Ecklonia.* Other frequently occurring species are *Cystophora paniculata* (Turn.) J. Ag., *Carpoglossum confluens* (R. Br.) Kuetz., *Dictyopteris muelleri* (Sonder) Schmidt, and *Sargassum verruculosum* (Mert.) J. Ag. with its slender axis often several feet long, buoyed up by exceptionally large vesicles. *Sargassum grande* J. Ag., probably the largest species of the genus in these waters, may also be an important constituent in

places, sometimes reaching such density that the bottom is completely obscured by the great plants which ascend to the surface from a depth of at least 12 feet.

Bright patches of pink encrusting corallines and other encrusting red algae sometimes show through the cover of larger brown algae, and here and there are spread out horizontally brackets of the dull red *Ethelia australis* (Sonder) W. v. Bosse sometimes reaching 9 inches in diameter. Amongst other red species often seen in the sub-littoral are *Plocamium telfairiae* Harv., and *Polysiphonia cancellata.*

The Chlorophyta are sometimes represented by brilliant green pure patches of *Caulerpa hypnoides* (R. Br.) Ag. and more rarely by *Caulerpa brownii* Endl. and the smaller *Caulerpa sedoides* (R. Br.) C. Ag. Scattered filaments of the inconspicuous *Chaetomorpha aerea* (Dillw.) Kuetz., occur on the rocks and occasionally a tuft of the beautiful plumose *Cladophora feredayae* Harv. or the finer *C. gracilis* (Griff.) Kuetz. makes a bright green splash of colour.

Sponges are common in the crevices between the boulders and the large flattened shells of the inconspicuous, *Haliotus noevosa* Martyn often cling tightly to the rock faces.

2. *SEMI-EXPOSED SHORE*

The shores of this division are characterised by the appearance of the brown alga *Xiphophora billardieri* unaccompanied by either *Hormosira banksii* or *Sarcophycus potatorum,* the species characterising the " Sheltered " and " Exposed " shores respectively.

(*a*) *Supra- and upper-littoral*

The associations of this region have already been discussed when dealing with " Sheltered " shores though with the increased exposure they suffer some modification.

When the aspect is favourable encrusting lichen associations are again present though the bands are extended and elevated as compared with their representatives in " Sheltered " situations. *Lichina confinis* also is often well developed.

Bostrychia, on the other hand, cannot tolerate the more exposed conditions and is found only rarely, and then only as very poorly developed tufts in narrow crevices between the boulders.

Bembicium does not extend beyond the " Sheltered " shores, but *Melaraphe unifasciata* remains with an increased vertical range.

(*b*) *Mid-littoral*

The limpets are again well represented, other species sometimes joining the *Cellana* and species of *Siphonaria* mentioned previously. *Elminius* sp. is usually absent except very locally where it receives extra shelter, and its place is taken by *Chamaesipho columna,* another small species with a far greater vertical range extending from the lower *Lichina* to upper *Galeolaria.* With the increasing lack of locally sheltered

situations the numbers of *Tetraclita purpurascens* dwindle but in addition, in the more exposed parts, the large surf barnacle *Catophragmus polymerus* Darwin, occurs. This, though more characteristic of " Exposed " shores, is sparsely developed in some places in this division.

Rivularia australis occurs seasonally in much the same position as on " Sheltered " shores, but here is often less well developed.

Chordaria dictyosiphon, Hildenbrandtia sp. and *Monostroma* sp., are all plants of the " Sheltered " shores and have not been found here.

(1) *Galeolaria-Gelidium* association.

The *Galeolaria* approaches its limit of tolerance to exposure in the more exposed parts of these " Semi-exposed " areas and in such places is very sparsely developed. With the accompanying *Gelidium* which shows a similar or slightly reduced exposure tolerance, it is present in a well developed band along most of these shores though it certainly shows maximum development in less exposed positions. There being no competing band of *Hormosira* it extends almost to the upper boundary of the *Xiphophora* association. Other algae do occur, however, over the tubes; *Ulva* is often present somewhat seasonally though usually not as thickly as in the " Sheltered " localities, and perhaps the species most commonly present is *Bryocladia ericoides* (Harv.) Schmitz a small setaceous Rhodophyte forming black mat-like patches particularly in the lower part of the *Galeolaria* band which provides such an excellent substrate. Also in the lower part of this band are often a few plants of *Laurencia botryoides.* Where slope is very gentle *Ceramium fastigiatum* Harv. may occur both above and within the *Galeolaria* forming extensive soft dull red, velvet-like colonies often 6-12 inches in diameter. Other small species at times form low colonies, and compact tufts of *Cladophora flexuosa* in some places occur in the upper part of the *Galeolaria.*

(c) Lower littoral

(2) *Corallina* fringe.

Bounding the *Xiphophora* association along its upper margin is a narrow fringe of low shrubby *Corallina officinalis* L. occupying a narrow strip of shore generally no more than 1-3 inches in vertical extent. In the absence of the protecting *Hormosira,* this species seems unable to ascend any higher into the littoral and bounds the *Xiphophora* association much as the narrow strip of white *Galeolaria* bounds the *Hormosira* on very sheltered shores. Depending upon the density of the *Xiphophora* it may penetrate for 1 foot or sometimes more below this narrow band, but a dense cover of *Xiphophora* may exclude it almost completely. On vertical faces, particularly where shaded, the rigid *Corallina officinalis* is often replaced by the more lax *C. gracilis.*

Bryocladia ericoides sometimes mingles with the fringe and another small species often associated with it is *Lophurella hookeriana* (J. Ag.) Falk., its tufts of terete black branches being much the same height as the *Corallina.* Stunted *Laurencia botryoides* occurs occasionally.

The fringe often suffers from excessive exposure and insolation during summer and the calcareous tufts may then be bleached to a bright white.

(d) Sub-littoral fringe

(3) *Xiphophora* association.

The limit of tolerance of *Xiphophora* for shelter and of *Hormosira* for exposure correspond fairly closely so that there is very little overlapping of the two associations. Where both are found on the same shore the limits of neither association are well defined but on the whole, the *Xiphophora* seems to appear about 1 foot below the upper limit of *Hormosira*.

Where well developed, the narrow strap-shaped thalli form a practically pure association with a sharply defined upper margin bounded by the *Corallina* fringe. As already mentioned the *Corallina* may extend some distance into the association but is generally soon replaced by the encrusting corallines. The vertical extent of the association varies as a rule between 1 and 3 feet generally thinning out before reaching the *Phyllospora* association, and this region between the main part of the *Xiphophora* association and the upper part of the *Phyllospora* is often a rich collecting ground for the larger red algae. This is so particularly on bouldery shores where in this sub-littoral fringe together with numerous other species there have been collected *Plocamium costatum* (J. Ag.) Hook. and Harv., *P. telfairiae, Laurencia elata* (C. Ag.) Harv., *Gelidium australe* J. Ag., *Chondria* sp., and *Champia tasmanica* Harv. On these bouldery shores *Codium fragile* may also be present in the lower part of the *Xiphophora* band, and *Ulva lactuca* excluded from the denser parts of the *Xiphophora* association may sometimes reappear here. The grey-green tufts of the bristle-like *Chaetomorpha aerea* often occur particularly on shaded rocks where they are frequently developed on the coating of encrusting corallines, and the beautiful *Chaetomorpha darwinii* (Hook.) Kuetz. with its filaments of large glistening turgid cells like a string of green beads often occurs attached to other algae. Brown algae including *Cystophora* spp., *Zonaria subarticulata* and *Ecklonia radiata* may also be present in the lower parts of the association though the latter two are typically plants of deeper water.

(e) Sub-littoral

(4) *Phyllospora* association.

The *Phyllospora* association seems to reach its maximum development along these shores and is almost invariably present as a dense fringing bed of variable width depending on the steepness of the shore. Here the tall plants penetrate to somewhat deeper levels than along " Sheltered " shores.

Cystophora retroflexa is unable to withstand the increased exposure and is for the most part absent.

(5) *Macrocystis* association.

Macrocystis pyrifera again forms fringing beds often better developed than in " Sheltered " localities, and the vegetation of the sub-littoral seems in the main to be dominated by *Ecklonia radiata*.

3. *EXPOSED SHORE*

Included in this category are the eastern shores of Port Arthur from The Budget to a little north of Denman's Bay, the eastern and south-eastern shores of Point Puer and most of the rocky shore extending from Safety Cove to Half Moon Bay.

Though the prevailing wind is north-east, south-westerlies are frequent and it is these which bring into Port Arthur the big seas from outside which, crashing against the eastern shore often send spray to a height of 100 feet or more and make this stretch of shore one of the most exposed in Port Arthur.

Point Puer escapes the greatest force of these south-westerlies, and north-easterlies do not as a rule build up such large seas within Port Arthur. As a result of this escape from the most intense wave action coupled with the presentation of roughly horizontal and vertical rather than sloping faces, the vegetation here presents some differences from that of the eastern shore. However, all these shores have one species in common, the massive "Bull Kelp", *Sarcophycus potatorum*.

3A. *EXPOSED SHORE OF POINT PUER*

At Point Puer there appear the shaly mudstone cliffs, up to 100 feet high, of laminated mudstone ranging in colour from cream to light-brown and grey (see Plate 9). In general there is a gradual increase in the hardness of the strata from top to bottom of the cliffs, the upper layers being easily dug out with a pocket knife and frequently showing signs of falling away in small sections while in the littoral zone the severe buffeting of the waves causes no such rapid and noticeable erosion though falls occur occasionally at the junction of platform and cliff face where there is sometimes a certain amount of undercutting. These wave-cut platforms have been mentioned by Newton and Cribb (1951).

In places, a series of platforms each dropping to the next by a step of 2-8 feet has been formed but where this happens the platforms are generally comparatively narrow and often no wider than 6-8 feet. Elsewhere however platforms may reach a width of 40 feet or more.

Along the eastern exposure of the point the strata in the southern half dip gently to the south-west and along the northern half to the north-west so that in several places a platform tilted gently landwards may gradually emerge from the sub-littoral and at various points occupy different positions in the sub-littoral and littoral zones so that each algal association is in turn spread out horizontally over the platform surface. Along the south-eastern shore there is apparently less variation in the resistance of the strata continually exposed to the eroding action of the waves and the cliffs often drop sheer into the sea or occasionally by a series of very narrow platforms or ledges each separated by a step of 6 feet or more.

Along this shore also there have been eroded several caverns the largest about 30 feet wide and 20 feet high at the mouth and approximately 100 feet long. Unfortunately, little description can be given of the flora of these caves as they are quite inaccessible from land and being situated on the most exposed part of Point Puer, to take a boat inside is

hazardous even in the calmest weather. But from observation made near the entrance it appears that quite close to the mouth all the larger and shrubby species disappear leaving only the encrusting corallines which give way further in to the more shade tolerant *Hildenbrandtia* which forms a smooth dull-red covering over the rock surface.

(*a*) *Supra-littoral*

(1) Lichen associations.

The lichen associations of the supra-littoral differ from those already described for the dolerite shore, and though where a southerly aspect is locally available *Ochrolichina parella* and *Patellaria rimosa* may appear, particularly on the harder strata, these species never form the distinct bands formed on the dolerite. The softer substrate seems unsuitable for their growth and even where present the colonies are not readily detected against a pale-cream background of mudstone. However, these cliffs do support quite a rich though inconspicuous lichen flora, one of the most common members being a species of *Buellia*. On the south-eastern shore at a point where a landing was made there is some development of the orange-yellow lichen association extending upwards for about 70 feet from a point 10-12 feet above the *Sarcophycus*. A species of *Collema* appears about 3 feet above the lower limit of this association and occupies a band 30-40 feet wide which must frequently be drenched with salt spray.

Lichina confinis appears on Point Puer only rarely.

(2) Supra-littoral pools.

There occur occasionally on the supra-littoral platforms a few wide shallow pools fed by spray from heavy seas. One of these which received a certain amount of freshwater seepage and which during heavy rain must become nearly fresh, was almost entirely covered with a carpet of *Enteromorpha* sp., while another smaller pool less likely to be affected by seepage was lined with a dense olive-green fur up to 3 inches long of *Lyngbya confervoides* Ag.

(3) *Prasiola* community.

At two point on the south-eastern exposure of Point Puer a species of *Prasiola* occurs on the cliff face below the roosts of shags and gulls and in one case extends as a prominent green stain from almost the top of the cliffs to approximately H.W.M. *Prasiola* is a genus which has commonly been reported from cool temperate and polar regions particularly in areas enriched by nitrogenous matter. The shaded aspect of these cliffs particularly during winter when they receive hardly any direct sunlight probably favours the development of the species and during January and February only a trace of the community can be found in the lower part of its range.

(*b*) *Upper littoral and mid-littoral*

The littorinid *Melaraphe unifasciata* may enter the upper part of this region but is more usually found in the lower part of the supra-littoral which often receives considerable spray. However, a smaller and usually less common species *M. praetermissa* (May) may sometimes be found throughout the upper littoral. But as in sheltered and semi-

exposed localities this part of the shore is frequently bare of algae and is dominated by the small barnacle *Chamaesipho columna*. This is a species with a very definite preference for horizontal or gently sloping surfaces and though a few individuals do occur on the vertical steps it is on the platform surface that it reaches maximum development. Here the tall narrow shells up to three-quarters of an inch high are very densely crowded and spread as a spiny grey sheet over the smooth platform surface.

In a few places a species of *Verrucaria* forms a close black intermittent crust on the rock surface between the barnacles and sometimes on the lower part of the shell.

Brachyodontes rostratus sometimes appears densely in the lower parts of the *Chamaesipho* range, the narrow spaces between the barnacles providing an excellent alternative to the cracks and pits of the rock surface to which this small mussel is usually restricted.

In the lower part of the mid-littoral below the *Brachyodontes, Mytilus planulatus* is often conspicuous, occurring singly, in small groups or dense patches several feet across. The colonies occur particularly, though not necessarily, in very slight depressions and in such positions *Corallina officinalis* may mingle with the shells where not too densely placed.

Ulva is common on the *Mytilus* and it is at about this level that there sometimes appear a few plants of the fleshy brown *Splachnidium rugosum* (L.) Grev. and of *Adenocystis utricularis* (Bory) Skottsberg, a small brown species in the form of a tough velvety elongate-pyriform vesicle 1-2 inches long and usually filled with water. Though it extends into the lower littoral, the surf barnacle *Catophragmus polymerus* is often common at this level and frequently grows on the shells of *Mytilus*. Like *Chamaesipho* it shows a decided preference for horizontal and gently sloping surfaces and in such a position where the foaming surf races across the platform the large scaly white shells may be very closely placed.

(4) *Porphyra* and *Scytosiphon* associations.

During winter and spring months there is developed on parts of Point Puer, two seasonal algal associations constituted by *Porphyra umbilicalis* and *Scytosiphon lomentarius* respectively. These associations occupy the mid littoral and sometimes the lower part of the upper littoral but on Point Puer they tend to be rather sporadic in occurrence and the reasons for their presence and absence is not always readily apparent. It is even difficult to determine the relative positions of the two species, sometimes one appearing to occupy the higher level and sometimes the other, but whatever their relative positions both are almost entirely pure associations and there is hardly any mingling of the two species.

The lower plants of *Scytosiphon* are generally constricted tubulose and semi-fleshy while the upper ones are lax, thin, flattened tubes which densely plaster the rocks as the waves recede and after prolonged exposure may become almost brittle dry.

(c) *Lower littoral*

(5) Encrusting coralline association.

The uppermost algal association of the lower littoral is the encrusting coralline association characterized by two species either of which may be present alone though generally occurring together.

The first of these two is a pale-pink encrusting species which on the very greatly sloping platform surface appears generally in the lower part of the *Catophragmus* range. At first it is restricted to the very shallow depressions and cracks, but lower down it forms a complete dull fine cover over the rock surface. Over this coating there generally occur a number of algal species which vary considerably with the level, degree of shade, distance from the platform edge and other factors. *Mytilus* and *Catophragmus* are generally present at least in the upper parts and the limpets *Siphonaria diemenensis, Patellorida marmorata* (Ten.-Woods), and *Cellana* sp. are nearly always common and often associated with an occasional chiton. A few tubes of *Galeolaria caespitosa* may be scattered here and there, where the exposure is not maximal, but in these positions, where it is very close to its limit of tolerance of exposure, it never forms the distinct band found on more sheltered shores and is without the usually accompanying *Gelidium pusillum.* Green tufts of *Ulva* are scattered here and there, and *Corallina officinalis* often colonizes small shallow pools or depressions. Succulent-spongy clumps of *Polysiphonia macrarthra* Zan. are widely scattered and *Adenocystis utricularis* sometimes appears in small numbers. One of the most noticeable species is a small semi-prostrate *Ceramium* which forms large velvety dull-red colonies at first circular but later ring shaped and up to 9 inches in diameter.

The other species characterising the association is *Lithophyllum hyperellum f. fastigiata* Fosl. a species nearly always found on shores supporting *Sarcophycus,* and like it, always indicative of very exposed conditions. It is a most striking species forming pinkish to biscuit-brown cushion- or dome-shaped colonies up to 3 inches in diameter (see Plate 8.) The colonies are firmly attached to the rock surface and the densely placed erect and radiating branches which become partly fused form a dense coralloid mass with a beautifully rounded outer surface. Both vertical and horizontal faces support the colonies but it is near the seaward margin of the platform surface that the most symmetrical and well developed colonies are found. But even here, injury, an uneven surface or contact with other species may result in some distortion of the colonies. When broken from the substrate they are seen to be sheltering a large number of the small bivalves *Lasaea australis* Lam. The branches in the mid part of the colony often show a dull blue-green colour and this is caused by the perforating alga *Entophysalis deusta* (Meneghini) Drouet and Daily.

On the vertical margins of the platforms these encrusting species form a fairly distinct band. The width of this band averages 3-6 inches but is very responsive to variation in degree of light intensity, a low intensity resulting in an increase in the width while greater insolation may cause its almost complete disappearance. In the more shaded positions favouring an increased development, *Ralfsia* sp. frequently appears as sharply contrasting black encrusting colonies at first circular but later often ring shaped and up to one foot in diameter. The lowermost part of the crust on vertical faces often carries tufts of *Corallina gracilis,* a lax species with pendulous branches arising from a dense basal disc, and this too is favoured by increasing shade.

(6) *Laurencia* association.

The vertical faces along parts of Point Puer provide some of the best examples of sharp banding available at Port Arthur, and the coralline crust is replaced below with remarkable suddenness by a dense dark band of red algae with a particularly sharp though somewhat irregular upper margin (see Plate 5). During the colder months the dominant species in positions of average illumination is *Laurencia botryoides*, the low bushy plants forming a dense dull-red scrub seldom over two inches high. Associated with the *Laurencia* are nearly always a number of other small Rhodophytes generally of a dark-red or almost black colour. These include *Bryocladia ericoides, Lophurella hookeriana, Gigartina ancistroclada* Mont., *Ballia scoparia* Harv., and most important, *Lophurella periclados* (Sonder) Schmitz, with erect branches each bearing towards the apex a dense club shaped mass of finer lateral branches. Where a platform occurs at a suitable level this association is spread out over the platform surface as a close low turf varying in composition as shelter increases slightly away from the platform margin. Other species may also join the association and these include *Gigartina* sp., *Codium fragile* and occasionally stunted plants of *Hormosira*. *Lophurella periclados* is rather more tolerant of shady conditions than the *Laurencia* and may be the main constituent of the band when reduced light intensity has removed the *Laurencia*. In these positions the dull grey-green tufts of the bristle-like *Chaetomorpha aerea* may be a common though inconspicuous constituent of the association. Unlike the *Lophurella, Laurencia* is markedly seasonal and during January and February only the basal parts of the plants sometimes with a few bleached and decaying branches can be found. However, the other constituent species seem to make good the loss and there is no very noticeable reduction in the density of the band. Where gaps appear in the association the encrusting corallines generally occupy the uncolonised surface and *Corallina gracilis* also penetrates the band where it becomes sparse particularly as a result of shading. A few tufts of *Chaetomorpha darwinii* sometimes occur among the *Laurencia* and short scrubby clumps of *Ulva* may appear epiphytically, but these form only a very small proportion of the algal cover and the association is predominantly a Rhodophycean one. The width of the band generally varies between 3 and 6 inches, and like that of the lithothamnion association above it is influenced by variation in light intensity, reduced insolation often resulting in extension.

(d) Sub-littoral fringe

(7) *Xiphophora* association.

The dark Rhodophycean band is sharply bounded below by the contrasting yellow-brown of *Xiphophora billardieri* which constitutes the succeeding band (see Plate 5). Plants in the upper inch or two of the *Xiphophora* range are often short and stumpy and here there may be some mingling with the lowermost individuals of the *Laurencia* association, though in the main the boundary between the two associations is very sharply marked.

The long narrow forked straps generally 1-2 feet long taper gradually from a width of about a quarter of an inch to a fine point, and as the waves recede the dense fringe of branches hangs laxly downwards often completely obscuring the rock surface for a distance of 2-3 feet. The

branches are quite without epiphytes and though a pink coralline crust may enter the lower part of the band, the association is in the main a fairly pure one and within the band of holdfasts, generally 12-18 inches, in width there are few other algae, at least where the association is well developed. But where for some reason the *Xiphophora* becomes sparse the *Laurencia* may often descend for another foot. Cranwell and Moore (1938) on the other hand report a varied and well developed understory to the *Xiphophora* association in New Zealand.

A conspicuous plant of the *Xiphophora* association is *Lessonia corrugata* Lucas. The massive branched holdfast is generally attached within the *Xiphophora* band and from it arise a great dark-brown mass of deeply corrugated strap shaped blades half to one inch in diameter and up to 6 feet long. These blades, often 200 or more from a single holdfast, are extremely strong, pliant and elastic, and though continually being worn away at the tip are replaced, at least for a time, by meristematic activity near the base. The blades are usually free from epiphytes though the holdfasts sometimes carry a coating of lithothamnia and a few small algae. The species forms a distinct band only in very localized positions and usually occurs scattered here and there along the *Xiphophora* band particularly in its lower parts. It is more tolerant of shade than *Xiphophora* and though probably able to withstand a greater buffeting than *Xiphophora,* it cannot survive the extreme exposure tolerated by *Sarcophycus.*

The *Xiphophora* can probably be regarded as forming a sub-littoral fringe though in the absence of *Sarcophycus* it may extend into the sub-littoral and on one occasion was seen at a depth of approximately 12 feet below E.L.W.S. However, these occurrences are exceptional, and in the main it is confined to the fringing band.

The downward extension of each of these three bands in the absence of the succeeding association suggests that each is prevented from attaining a full expression of its vertical range by competition with the association below it, though competition does not appear to be a limiting factor in the upward extension of the bands.

(e) Sub-littoral

(8) *Sarcophycus* association.

The *Xiphophora* is replaced below by an association dominated by one of the most striking algal species in Tasmanian waters, the large brown " Bull Kelp ", *Sarcophycus potatorum.*

A few plants sometimes appear near the upper limit of the *Xiphophora* association but in the main it occurs in quantity only below the *Xiphophora* band which its presence may reduce in width.

The uppermost plants may be regarded as belonging to the sub-littoral fringe, but dense submarine forests are formed at depths at least 12 feet below E.L.W.S. and it must be regarded as an association of the upper sub-littoral with its uppermost representatives entering the sub-littoral fringe.

The plant is attached by a large disc-shaped holdfast often 9 inches in diameter and from this arises a massive stipe 8-24 inches long sometimes attaining a diameter of 3 inches. This stipe though extremely

strong is of a somewhat rubbery consistency and is fairly pliant though rigid enough to remain fairly erect when the waves recede. At its upper and it becomes flattened and passes into a broad lamina. This is of the consistency of heavy leather and up to a quarter of an inch thick, and though at first an unbroken sheet up to 12 inches wide, upwards it divides in a roughly palmate manner into broad repeatedly and irregularly forked gradually tapering strap shaped segments near the apex often coarsely undulate and with a spiralled appearance. The total length in large specimens may often reach 15 feet or more. In some plants branches are borne in a pinnate manner or very short stipes along the margin of the individual portion of the main lamina and each of these in turn may be pinnately branched at the base and split into long tapering segments above. It is almost impossible to pull even a small plant from the rocks and an examination of drift specimens seems to indicate that their detachment is often due to the flaking away of the substrate rather than to any weakening of the holdfast itself.

Vertical faces will support the *Sarcophycus* but at Point Puer it reaches maximum development on or near the platform margins where the massive plants are lifted by the swell and crashed on to the pavement lashing it with a multitude of heavy laminae as it is withdrawn again by the foaming mass of water cascading off the platform (see Plate 7). During low water on a calm day the gentle swell lifts the weight of the lamina and the rhythmical movements of a stand of erect stipes near the platform margin vaguely suggest from a distance the motion of a group of black swans.

The great battering the plants receive is probably at least partly responsible for the almost complete absence of epiphytes over the whole plant. On a couple of occasions a short fur of *Ectocarpus confervoides* was found on a partly decayed lamina but apart from this the only species found is an, as yet, undescribed species of *Compsonema*, which frequently forms small rounded or ring shaped colonies up to half an inch though generally less in diameter. These do not appear to be responsible for the large holes so commonly occurring in the thallus. According to Whitting (1893) these holes are caused by the parasitic *Chlorocystis sarcophyci* Whitting but no sign of this species has been found in the Port Arthur specimens.

Durvillea antarctica (Cham.) Hariot which forms a comparable association in New Zealand appears to occupy a slightly higher level on the shore occurring, according to Oliver (1923), in the lower part of the mid-littoral. Oliver mentions that the segments of the thallus are usually broken off at the ends but this is hardly ever the case with *Sarcophycus* though the laminae do show signs of being continually worn away at the margins. *Sarcophycus* seems to be of a much more pliant consistency and the narrow laminae sometimes become tied in tight thumb knots without showing any sign of cracking.

Oliver also notes the honeycombing of the holdfast by various moluscs, but this caverning is seen only to a very limited extent in *Sarcophycus*. Certainly in an attached plant there are no visible signs of these cavities as figured by Herriott (1923) for *Durvillea antarctica*, though when a holdfast is removed from the rock a certain amount of channeling is revealed. This results from the activities of a small white amphipod,

but usually does not extend far into the tissues and seems seldom to reach a stage where the efficiency of the holdfast is seriously impaired. Oliver reports a variety of animals in the *Durvillea* holdfast but the amphipod is the only species found in the *Sarcophycus*.

The *Sarcophycus* association also differs from the *Durvillea* association in having very little understory, at least in its upper parts. Oliver reports a fairly dense growth of various smaller algae occurring among the *Durvillea* stipes but at Port Arthur this second story is very poorly developed. Often the only alga occurring in quantity is an encrusting coralline which in the mid and lower parts of the association may almost completely cover the rocks beneath the *Sarcophycus*, its bright pink crust contrasting strongly with the pale-yellow discs of the *Sarcophycus* holdfasts.

(9) *Phyllospora* association.

Phyllospora comosa can be seen in the upper sub-littoral in places along this shore. For the most part the platforms drop sharply into deep water and it is difficult to see anything but the uppermost part of the sub-littoral vegetation. However, the *Phyllospora* is fairly common sometimes reaching a length of at least 10 feet and it probably forms an indefinite association below the *Sarcophycus* at a depth somewhat greater than that in sheltered localities.

A number of Rhodophytes are found cast up only after bad storms and most of these probably come from the lower sub-littoral in these exposed positions. They include *Ballia robertiana* Harv., *B. mariana* Harv., *Plocamium coccineum var. flexuosum* Harv., *Ptilonia australasica* Harv., *Gelidium glaudulaefolium* Hook. and Harv. and several others.

(10) *Macrocystis* association.

Macrocystis fringes this shore showing very good development in water up to 45 feet deep, and when dense, has a small effect in reducing the severity of the swell reaching the shore (see Plate 9).

3B. *EXPOSED EASTERN SHORE OF PORT ARTHUR*

The eastern shore of Port Arthur is a comparatively unbroken stretch of coast about three miles in extent and subject to increasing exposure southwards. The shore is for the most part steep and dolerite slopes of 30° and often more rise often to 50 feet above the sea, while in places dolerite cliffs sometimes showing organ pipe structure fall vertically into the sea without any intervening slope. There is always considerable swell along this shore and in only a couple of places has it been possible to effect a landing. The rough nature of the country makes approach by land impracticable so most of the observations have had to be made from a boat.

The exposed shores from Safety Cove to Half-Moon Bay are likewise not readily accessible, and the algal vegetation here appears to be, in the main, similar to that occurring on the exposed eastern shore.

(*a*) *Supra-littoral*

(1) Lichen association.

Conspicuous lichen bands are for the most part lacking along this shore. The orange-yellow association is feebly developed in places while

the association of white lichens is almost entirely absent except where a southerly aspect is locally available in the gulches which interrupt the shore at intervals. Here it appears once again about 15 feet or more above the *Sarcophycus* densely covering the rocks for several feet while the opposing face of the gulch presents an apparently entirely uncolonised surface.

(*b*) *Upper littoral and mid-littoral*

The distribution of the animal inhabitants of these zones follows much the same lines as on Point Puer though the bands tend to be vertically extended and since the slopes are not broken up by platforms at various levels the banding is in most cases clearer. *Chamaesipho columna* again forms a dense cover on slopes of up to 30° but becomes sparser with increasing steepness and almost disappears on vertical faces. It appears about 6-10 feet above the *Sarcophycus* and extends upwards with a vertical range of up to 6 feet. *Melaraphe unifasciata* occurs among the uppermost individuals but its main region is above this and it has been found as high as 25 feet above the *Sarcophycus*. *Melaraphe praetermissa* occurs in the upper and mid part of the *Chamaesipho* range. *Lichina confinis* sometimes appears in the upper part of the *Chamaesipho* range particularly where exposure is not maximum but on the whole it is poorly developed along this shore. *Brachyodontes rostratus* is of common occurrence in the lower part of the *Chamaesipho* band, reaching a maximum density on slopes of less than 30°. *Catophragmus polymerus*, also favouring gentle slopes, is very well developed in the lower mid-littoral and descends well into the lower littoral. Limpets occur on the vertical faces but are not so common on the gentle slopes and it seems probable that the *Catophragmus* occur with such density that the movement of the limpets over the rock surface is impeded or prevented. Where more or less horizontal or very gently sloping surfaces are locally available these barnacles are often densely scattered over the surface of a patch of *Mytilus planulatus* which appears throughout Port Arthur from positions of extreme shelter to extreme exposure.

(2) *Porphyra* association.

During winter and spring an almost pure association of *Porphyra umbilicalis* may form a band occupying the mid-littoral. Generally, however, it is poorly developed and discontinuous on the eastern shore and the association is seen at its best on the exposed western shore between Safety Cove and Half Moon Bay. Here there occurs on both sloping and erect faces a distinct band of *Porphyra* with a vertical range of about 2 feet its lower limit is approximately 18 inches above the *Sarcophycus*, and on sloping surfaces which it favours the dense mass of crisped and ruffled fronds form a layer 2 inches deep completely covering the rocks (see Plate 6). In the lower and mid parts of its range the plants are of a deep olive green colour but near the upper margin of the band they tend to be smaller and somewhat bleached, and after emergence for some time they plaster the rocks with a close, shiny, lilac-pink crust. Above the *Porphyra* there is often a narrow indistinct band of *Bangia fuscopurpurea* (Dillw.) Lyngb. This usually does not exceed 6 inches in vertical extend and there is some mingling with the upper part of the *Porphyra* association.

(c) Lower littoral

(3) Encrusting coralline association.

Along most of this shore the encrusting coralline species seen on Point Puer are absent and they appear only locally where more sheltered conditions are available as on the vertical sides of the gulches. A coralline association is still conspicuously present, however, and is represented by the second species, *Lithophyllum hyperellum f. fastigiata* forming a distinct white band above the *Sarcophycus*. The colonies are closely placed, often confluent and depressed, and at least in the upper part of the band are often crowded by *Mytilus* and *Catophragmus* so that they are very frequently distorted and seldom present the beautifully symmetrical appearance of colonies on the platforms of Point Puer. Plate 8 shows a sloping shore, not subject to maximum exposure, where *Lithophyllum* is sparsely developed with *Catophragmus* above the *Sarcophycus*.

(4) *Laurencia* association.

On the very exposed sloping faces the association is almost entirely absent though it reappears on vertical faces particularly where exposure is slightly reduced. The association shows some preference for vertical faces. but even here extreme exposure seems able to remove it.

(d) Sub-littoral fringe

(5) *Xiphophora* association.

On the most exposed slopes the *Xiphophora* association is either quite absent or present only as a few scattered plants just above the *Sarcophycus,* though vertical faces may carry the band in some places. The reasons for the appearance and disappearance of *Xiphophora* is complicated by the fact that along this shore the more shaded south-western faces are the ones usually more exposed to heavy swell and it is in general on the north-western faces that *Xiphophora* appears. From observations in other places there seems little doubt that *Xiphophora* lacks the shade tolerance of *Sarcophycus* and *Lessonia* but it also seems likely that extreme exposure too can cause its removal though it persists longer on vertical than on sloping faces. Though it is unlikely to be the full explanation, this preference for vertical faces may perhaps in part be determined by the *Sarcophycus* which is more at home on the slopes and in these positions perhaps lashes the rock surface above it so severely as to discourage the *Xiphophora*.

(6) *Pyura* band.

On steep and vertical faces the *Sarcophycus* association is bounded above by the band of white or pale-pink encrusting corallines but on slopes of 30° and less in the most exposed positions there frequently appears an intervening band of *Pyura praeputialis* (Heller) which can be regarded as occupying the sub-littoral fringe. It has a vertical range usually not exceeding 6 inches and may mingle above with the *Lithophyllum* and below with the *Sarcophycus*. The leathery individuals are shortly cylindrical, up to 3 inches wide and 5 inches high and adjacent individuals are often fused into a very resistant firmly attached mass. A number of small Rhodophytes often occur on the *Pyura* but it has not been possible to collect specimens for determination.

Sarcophycus, Lithophyllum and *Pyura* are the three main shore inhabitants indicative of exposed conditions but with decreasing exposure *Pyura* is the first of these to leave the shore while *Sarcophycus* with a greater range of tolerance is the last.

(e) Sub-littoral

(7) *Sarcophycus* association.

At low water a dense fringe of *Sarcophycus* is exposed between swells along the whole of this shore, and, as usual, reaches greatest development on the gentle slopes while the plants are reduced in size on the vertical faces. As on Point Puer the association seems fairly pure though a clump of *Lessonia corrugata* may appear here and there. The *Sarcophycus* penetrates well into the sub-littoral and forms a dense submarine forest to depths of at least 15 feet. Beyond this depth it seems to be replaced by *Phyllospora comosa.*

(8) *Macrocystis* association.

Macrocystis pyrifera is absent along the greater part of this shore probably because of the sharp descent to depths of 13-14 fathoms which is in excess of the depths at which *Macrocystis* usually grows. If attached to the steeply sloping face at suitable depths the delicate terminal blades would be unlikely to survive long the constant friction with the rock surface which would undoubtedly occur along this shore.

Figure 2 shows a generalised representation of the zonation found on rocky shores of moderate slope and varying exposure at Port Arthur, and Section V lists the associations with their more important animal and plant constituents.

B. SAND AND SAND-MUD FORMATION

1. *SHELTERED SHORE*

The *Zostera* associations characteristic of sand-mud flats in the most sheltered positions are well developed on the extensive flats occurring in the northern end of Long Bay and the western part of Opossum Bay. Two species are involved, *Zostera muelleri* Irmisch in the lower littoral and *Z. tasmanica* Mart. in the sub-littoral.

(a) Lower littoral zone

(1) *Zostera muelleri* association.

Zostera muelleri is a small species, seldom exceeding 6 inches in length, which forms a fine sward not always completely covering the substratum. It occupies a band extending from about the level of the upper limit of the *Hormosira* association down to approximately E.L.W.S. Apart from algae from lower levels which are deposited on the association and apparently survive for some time there are comparativly few macroscopic algal associates. Where stones occur *Hormosira* frequently appears, and clumps of *Gracilaria confervoides* (L.) Grev. *Polysiphonia fuscescens, Cladophora fascicularis* (Mert.) Kuetz. and *Enteromorpha clathrata* (Roth) J. Ag. generally attached to pebbles or shells may be widely scattered over the flat. The clumps of *Gracilaria* carry a great variety of microscopic epiphytes including *Erythrotrichia carnea* (Dillw.) J. Ag.,

E. reflexa (Crouan) Thuret several species of diatoms, including *Schizonema* sp., and a number of filamentous and unicellular blue-green algae. Colonies of the blue-green *Merismopoedium glaucum* (Ehr.) Naeg. have been found in washings from the *Gracilaria*. On the shells of dead bivalves, which often litter the flat, the black *Isactis plana* (Harv.) Thuret sometimes forms firm closely appressed flat colonies while the shells themselves are often stained a dull blue-green by the perforating alga, *Entophysalis deusta*.

A bivalve, probably *Marcia* sp. and a turret shell, *Pyrazus australis* (Quoy and Gaimard), are often common over the flat, the former partly or shallowly buried, and in some places, particularly less muddy areas, the surface is thrown into numerous small hummocks often a couple of inches high and 6-9 inches across, probably caused by a burrowing *Lutraria*-like mollusc.

(*b*) *Sub-littoral zone*

(2) *Zostera tasmanica* association.

This species appears at approximately E.L.W.S. and overlaps to a slight extent with the *Zostera muelleri* association above. It forms a very dense cover completely obscuring the bottom and extends to depths of at least 12 feet below E.L.W.S. The leaves are borne towards the top of an erect stem which increases to considerable lengths, often 4-5 feet in deeper water, and even near the upper limit of the association, the stems are frequently 2 feet long. At low tide on still summer days the uppermost layer of the mass of *Zostera* left in shallow water may partly emerge and suffer some injury from desiccation. During the late summer months the plants in general show very noticeable signs of decay and stems from which most of the leaves have rotted away frequently protrude above the surface at low tide (see Plate 10).

Unaccountably bare patches, thickly strewn with dead shells, appear here and there within the association and in deeper water large starfish and sea urchins are commonly seen. Bare patches which occur in shallow water are the favourite grounds of fishermen spearing flounder.

Associated with the *Zostera* are a considerable quantity and variety of algae. During the summer when many of the plants are decaying the partly denuded stems carry a heavy epiphytic growth of *Hydrocoleum glutinosum* and *H. lyngbyaceum* Kuetz. which form mucous—gelatinous, often vesiculate, olive-green masses, loosely attached and often matting together the decaying leaves of the *Zostera*. The small curled limy tubes of *Spirorbis* sp. often occur thickly over the surface of leaves and stems and a fine encrusting coralline, probably a *Melobesia*, is commonly present. The lower denuded parts of the stems frequently carry small sparse brown tufts of *Sphacelaria biradiata*, and *Jania micrarthrodia* Lamx. shows its best development in the more exposed parts of the association where it forms rounded clumps 1-2 inches in diameter. Brown gas-filled bladders of *Colpomenia sinuosa* are often conspicuous and a species of *Ectocarpus*, which has not been found in a fertile condition, occurs loosely attached to the *Zostera*, and, particularly in winter, forms great furry brown expanses in the upper part of the association. Sometimes a species of *Cladophora* also forms large plumose tufts, but never reaches the develop-

ment of the *Ectocarpus*. At the base of the *Zostera* plants is typically a mat of various algal species loosely attached to and entangled with the bases of the *Zostera* stems and with each other. The *Ectocarpus* occurs here also, but the main constituents of this basal mat seem to be *Chondria debilis* Harv. with its hooked branches and a small species of *Laurencia*. With these are generally found a variety of other species including *Polysiphonia fuscescens, Spyridia filamentosa* (Wulf.) Harv., and the springy curled filaments of *Chaetomorpha valida* (Hook and Harv.) Kuetz. together with various other species and a great variety of microscopic algae.

This basal algal mat appears at depths down to at least 3-4 feet below E.L.W.S., but *Zostera* growing in deeper water probably carries rather different algal associates and the following species which have not been collected in the upper part of the association have been found attached to *Zostera* drift which presumably came from deeper water:—*Hemineura frondosa* (Hook and Harv.) Harv., *Polysiphona dasyoides*, Zan., *Dictyota apiculata* J. Ag.

2. *SEMI-EXPOSED AND EXPOSED SHORE*

The exposed and semi-exposed beaches of clean white sand such as occur in Half Moon Bay, Safety Cove, and Stinking Beach support no macroscopic algae, though frequently after storms great masses of drift weed are piled up along the shore. *Macrocystis* is generally one of the main constituents of the drift, and the stipes from which blades and pneumatocysts are often broken by the pounding on the shore become rolled into great ropes, often one foot or more in diameter, partly embedded in the sand.

The beaches in places are backed by low sand dunes supporting *Pteridium aquilinum* (L.) Kuhn and other small species.

V. List of the Association with the More Important Animal and Plant Constituents

A. ROCKY SHORE FORMATION

1. *SHELTERED SHORE*

(*a*) *Supra-littoral*

(1) *Parmelia* association.
Lichens: *Parmelia perforata* (Wulf.) Ach.; *Parmelia conspersa* (Ehr.) Ach.; *Collema* sp.
Phanerograms: *Salicornia australis* Sol.; *Stipa teretifolia* Stend.

(2) *Ochrolichina* association.
Lichens: *Ochrolichina parella* (Linn.) Massal; *Patellaria rimosa* Muell. Arg.

(*b*) *Upper littoral*

(3) *Candelariella* association.
Lichens: *Candelariella vitellina* (Ehrh.) Muell. Arg.; *Teloschistes parietinus* (L.) Norm; *Gasparinia murorum* (Hoffm.) Dodge and Baker.

(4) *Verrucaria* association.
Lichens: *Verrucaria microsporoides* Nyl.

(5) *Lichina* association.
Lichens: *Lichina confinis* (Muell.) Arg.
Animals: *Melaraphe unifasciata* (Gray)

(6) *Bostrychia* association.
Algae: *Bostrychia mixta* Hook. and Harv.; *B. simpliciuscula* Harv.; *Caloglossa leprieurii* (Mont.) J. Ag.; *Hildenbrandtia* sp.; *Enteromorpha* sp.; *Rhizocolonium riparium* (Roth.) Harv.; *Hydrocoleum glutinosum* (Ag.) Gom.

(*c*) *Mid-littoral*

Animals: *Bembicium melanostoma* (Gmelin); *Elminius* sp.; *Tetraclita purpurascens* (Wood); *Siphonaria zonata* Teneson-Woods; *S. Diemenensis* (Quoy and Gaimard); *Cellana* sp.; *Brachyodontes rostratus* (Dunker).
Algae: *Gelidium pusillum* (Stackh.) Le Jol.; *Callithamnion* sp.; *Porphyra umbilicalis* (L.) J. Ag.; *Hildenbrandtia* sp.; *Scytosiphon lomentarius* (Lyngb.) J. Ag.; *Chordaria dictyosiphon* (Harv.) Kuetz.; *Enteromorpha* sp.; *Monostroma* sp.; *Rivularia australis* Harv.; *Calothrix* sp.

(7) *Galeolaria-Gelidium* association.
Animals: *Galeolaria caespitosa* (Lam.); *Hymeniacidon perlevis* (Montagu); *Ibla quadrivalvis* Cuvier.
Algae: *Gelidium pusillum* (Stackh.) Le Jol.; *Ulva lactuca* L.

(8) *Ulva* association.
Animals: *Galeolaria caespitosa* (Lam.).
Algae: *Ulva lactuca* L.; *Cladophora flexuosa* Harv.; *Bryopsis australis* Sonder; *Myrionema strangulans* Grev.; *Ralfsia* sp.

(*d*) *Lower littoral*

(9) *Hormosira* association.
Animals: *Galeolaria caespitosa* (Lam.); *Mytilus planulatus* (Lam.).
Algae: *Hormosira banksii* (Turn.) Decne.; *Corallina pilulifera* Post. and Rupr.; *Jania* sp.; *Lithothamnion incisum* Fosl.; *Gigartina* sp.; *Laurencia botryoides* (Turn.) Gail.; *Leathesia difformis* (L.) Aresch.; *Colpomenia sinuosa* (Roth) Derbes and Solier; *Notheia anomala* Bail. and Harv.; *Punctaria plantaginea* (Roth.) Grev.; *Ectocarpus mitchellae* Harv.; *Codium fragile* (Suringer) Heriot; *Ceramium paniculatum* Okamura; *Acrochaetium codicola* Boergs.; *Ulva lactuca* L.; *Polysiphonia fuscescens* Harv.; *Griffithsia monilis* Harv.; *Symploca hydnoides* Kuetz.

(10) *Cystophora torulosa* association.
Algae: *Cystophora torulosa* (R. Br.) J. Ag.; *Hormosira banksii* (Turn.) Dcene.; *Laurencia botryoides* (Turn.) Gail.; *Corallina pilulifera* Post. and Rupr.; *Jania* sp.; *Gigartina* sp.; *Corallina cuvieri* Lamx.; *Cystophora cephalornithos* (Labill.) J. Ag.

(*e*) *Sub-littoral fringe*

(11) *Cystophora cephalornithos* association.
Algae: *Cystophora cephalornithos* (Labill.) J. Ag.; *C. torulosa* (R. Br.) J. Ag.; *Sargassum laevigatum* J. Ag.; *Sphacelaria biradiata* Askenasy; *Corallina pilulifera* Post. and Rupr.; *C. cuvieri* Lamx.; *Jania fastigiata* Harv.

(12) *Sargassum laevigatum* association.
Algae: *Sargassum laevigatum* J. Ag.; *Cystophora cephalornithos* (Labill.) J. Ag.; *Cystophora spartioides* (Turn.) J. Ag.; *Sargassum muriculatum* J. Ag.; *Zonaria subarticulata* (Lamx.) Papenfuss; *Cladospephus verticillalus* (Lightf.) Ag.; *Corallina pilulifera* Post. and Rupr.; *C. cuvieri* Lamx.; *Jania fastigiata* Harv.

(*f*) *Sub-littoral*

(13) *Phyllospora* association.
Algae: *Phyllospora comosa* (Labill.) C. Ag.; *Polysiphonia cancellata* Harv.; encrusting corallines.

(14) *Cystophora retroflexa* association.
Algae: *Cystophora retroflexa* (Labill.) J. Ag.

(15) *Macrocystis* association.
Algae: *Macrocystis pyrifera* (L.) Ag.; *Polysiphonia frutex* Harv.; *P.* sp.; *Ectocarpus confervoides* (Roth) Le Jol.; *Ceramium* sp.; *Myrionema densum* Shottsberg.

(16) *Ecklonia* association.
Animals: *Haliotus noevosa* Martyn; sponges; bryozoans.
Algae: *Ecklonia radiata* (Ag.) J. Ag.; *Zonaria subarticulata* (Lamx.) Papenfuss; *Cystophora paniculata* (Turn.) J. Ag.; *Carpoglossum confluens* (R. Br.) Kuetz.; *Dictyopteris muelleri* (Sonder) Schmidt; *Sargassum verruculosum* (Mert.) J. Ag.; *S. grande* J. Ag.; *Cladophora feredayae* Harv.; *C. gracilis* (Griff.) Kuetz.; *Chaetomorpha aerea* (Dill.) Kuetz.; *Caulerpa brownii* Endl.; *C. sedoides* (R. Br.) C. Ag.; *C. hypnoides* (R. Br.) Ag.; *Polysiphonia cancellata* Harv.; *Plocamium telfariae* Harv.; *Ethelia australis* (Sonder) W. v. Bosse; encrusting corallines.

2. *SEMI-EXPOSED SHORE*

(*a*) *Supra- and upper littoral*

Animals: *Melaraphe unifasciata* (Gray).
Lichens: *Parmelia perforata* (Wulf.) Ach.; *P. conspersa* (Ehrh.) Ach.; *Ochrolichina parella* (Linn.) Massal; *Patellaria rimosa* M. Arg.; *Lichina confinis* (Muell.) Arg.

(*b*) *Mid-littoral*

Animals: *Siphonaria zonata* Teneson-Woods; *S. diemenensis* Quoy & Gaim.; *Celana* sp.; other species of limpets; *Chamaesipho columna* (Spengler); *Catophragmus polymerus* Darwin.
Algae: *Rivularia australis* Harv.
(1) *Galeolaria-Gelidium* association.
Animals: *Galeolaria caespitosa* (Lam.).
Algae: *Gelidium pusillum* (Stackh.) Le Jol.; *Ulva lactuca* L.; *Bryocladia ericoides* (Harv.) Schmitz; *Laurencia botryoides* (Turn.) Gail.; *Ceramium fastigiatum* Harv.; *Cladophora flexuosa* Harv.

(*c*) *Lower littoral*

(2) *Corallina* fringe.
Algae: *Corallina officinalis* L.; *C. gracilis* Lamx.; *Bryocladia ericoides* (Harv.) Schmitz.; *Lophurella hookeriana* (J. Ag.) Falk.; *Laurencia botryoides* (Turn.) Gail.

(*d*) *Sub-littoral fringe*

(3) *Xiphophora* association.
Algae: *Xiphophora billardieri* Mont.; *Corallina officinalis* L.; *C. gracilis* Lamx.; encrusting corallines; *Plocamium costatum* (J. Ag.) Hook. and Harv.; *P. telfairiae* Harv.; *Laurencia elata* (C. Ag.) Harv.; *Gelidium australe* J. Ag.; *Chondria* sp.; *Champia tasmanica* Harv.; *Codium fragile* (Suringar) Heriot; *Ulva lactuca* L.; *Chaetomorpha aerea* (Dillw.) Kuetz.; *C. darwinii* (Hook.) Kuetz.; *Cystophora* spp.; *Zonaria subarticulata* (Lamx.) Papenfuss; *Ecklonia radiata* (Ag.) J. Ag.

(*e*) *Sub-littoral*

(4) *Phyllospora* association.
Algae: *Phyllospora comosa* (Labill.) C. Ag.; encrusting corallines.
(5) *Macrocystis* association.
Algae: *Macrocystis pyrifera* (L.) Ag.
(6) *Ecklonia* association.
Algae: *Ecklonia radiata* (Ag.) J. Ag.; *Zonaria subarticulata* (Lamx.) Papenfuss; *Cystophora* spp.; *Carpoglossum confluens* (R. Br.) Kuetz.; *Sargassum* spp.

3. Exposed shore

3A. *EXPOSED SHORE OF POINT PUER*

(*a*) *Supra-littoral*

(1) Lichen associations.
Lichens: *Buellia* sp.; various other spp.
(2) Supra-littoral pools.
Algae: *Enteromorpha* sp.; *Lyngbya confervoides* Ag.
(3) Shaded and fertilised cliffs.
Algae: *Prasiola* sp.

(*b*) *Upper littoral and mid-littoral*

Animals: *Melaraphe unifasciata* (Gray); *M. praetermissa* (May); *Chamaesipho columna* (Spengler); *Brachyodontes rostratus* (Dunker); *Mytilus planulatus* (Lam.); *Catophragmus polymerus* Darwin.

Lichens: *Verrucaria* sp.

Algae: *Corallina officinalis* L.; *Ulva lactuca* L.; *Splachnidium rugosum* (L.) Grev.; *Adenocystis utricularis* (Bory) Skottaberg.

(4) *Porphyra* and *Scytosiphon* associations.

Algae: *Porphyra umbilicalis* (L.) J. Ag.; *Scytosiphon lomentarius* (Lyngb.) J. Ag.

(*c*) *Lower littoral*

(5) Encrusting coralline association.

Animals: *Mytilus planulatus* (Lam.); *Catophragmus polymerus* Darwin; *Siphonaria diemenensis* Quoy and Gaim.; *Patelloida marmorata* (Ten.-Woods); *Cellana* sp.

Algae: encrusting coralline spp.; *Lithophyllum hyperellum f. fastigiata* Fosl.; *Corallina officinalis* L.; *C. gracilis* Lamx.; *Polysiphonia macrarthra* Zan.; *Ceramium* sp.; *Adenocystis utricularis* (Bory) Skottsberg; *Ralfsia* sp.

(6) *Laurencia* association.

Algae: *Laurencia botryoides* (Turn.) Gail.; *Bryocladia ericoides* (Harv.) Schmitz; *Lophyrella hookeriana* (J. Ag.) Falk.; *L. periclados* (Sonder) Schmitz; *Gigartina ancistroclada* Mont.; *G.* sp.; *Ballia scoparia* Harv.; *Corallina gracilis* Lamx.; encrusting corallines; *Chaetomorpha aerea* (Dillw.) Kuetz.; *C. darwinii* (Hooker) Kuetz.

(*d*) *Sub-littoral fringe*

(7) *Xiphophora* association.

Algae: *Xiphophora billardieri* Mont.; *Lessonia corrugata* Lucas; encrusting corallines.

(*e*) *Sub-littoral*

(8) *Sarcophycus* association.

Algae: *Sarcophycus potatorum* (Labill.) Kuetz.; encrusting corallines.

(9) *Phyllospora* association.

Algae: *Phyllospora comosa* (Labill.) C. Ag.; encrusting corallines.

(10) *Macrocystis* association.

Algae: *Macrocystis pyrifera* (L.) Ag.

3B. *EXPOSED EASTERN SHORE OF PORT ARTHUR*

(*a*) *Supra-littoral*

(1) *Lichen* associations.

(*b*) *Upper littoral and mid-littoral*

Animals: *Melaraphe unifasciata* (Gray); *M. praetermissa* (May); *Chamaesipho columna* (Spengler); *Brachyodontes rostratus* (Dunker); *Mytilus planulatus* (Lam.); *Catophragmus polymerus* Darwin.

Lichens: *Lichina confinis* (Muell.) Arg.

(2) *Porphyra* association.

Algae: *Porphyra umbilicalis* (L.) J. Ag.; *Bangia fuscopurpurea* (Dillw.) Lyngb.

(*c*) *Lower littoral*

(3) Encrusting coralline association.

Animals: *Mytilus planulatus* (Lam.); *Catophragmus polymerus* Darwin.

Algae: *Lithophyllum hyperellum* f. *fastigiata* Fosl.

(4) *Laurencia* association.

Present only locally.

(*d*) *Sub-littoral fringe*

(5) *Xiphophora* association.

Poorly developed and intermittent.

(6) *Pyura* band.

Animals: *Pyura praeputialis* (Heller).

(*e*) *Sub-littoral*

(7) *Sarcophycus* association.

Algae: *Sarcophycus potatorum* (Labill.) Kuetz.; *Lessonia corrugata* Lucas.

B. SAND AND SAND-MUD FORMATION

1. *SHELTERED SHORES*

(*a*) *Lower littoral*

(1) *Zostera muelleri* association.

Animals: *Marcia* sp.; *Pyrazus australis* (Quoy and Gaimard).

Phanerogams: *Zostera muelleri* Roth.

Algae: *Gracilaria confervoides* (L.) Grev.; *Polysiphonia fuscesens* Harv.; *Erythrotrichia carnea* (Dillw.) J. Ag.; *E. reflexa* (Crouan) Thuret; *Cladophora fascicularis* (Mert.) Kuetz.; *Entermorpha clathrata* (Roth) J. Ag.; *Merismopoedium glaucum* (Ehr.) Naeg.; *Isactis plana* (Harv.) Thur.; *Entophysalis deusta* (Menegh.) Drouet and Daily.

(*b*) *Sub-littoral*

(2) *Zostera tasmanica* association.

Animals: *Spirorbis* sp.

Phanerogams: *Zostera tasmanica* Mart.

Algae: *Jania micrarthrodia* Lamx.; *Chondria debilis* Harv.; *Laurencia* sp.; *Polysiphonia fuscescens* Harv.; *P. dasyoides* Zan.; *Spyridia filamentosa* (Wulf.) Harv.; *Hemineura frondosa* (Hook. and Harv.) Harv.; *Melobesia* (?) sp.; *Colpomenia sinuosa* (Roth) Derbes and Solier; *Ectocarpus* sp.; *Dictyota apiculata* J. Ag.; *Sphacelaria biradiata* Asken.; *Cladophora* sp.; *Chaetomorpha valida* (Hook. and Harv.) Kuetz.; *Hydrocoleum glutinosum* (Ag.) Gom.; *H. lyngbyaceum* Kuetz.

2. *SEMI-EXPOSED AND EXPOSED SHORE*

(*a*) *Supra-littoral*

Phanerogams: *Pteridium aquilinum* (L.) Kuhn; other species of Phanerogams.

VI. Comparison with other Areas

From the foregoing it may be seen that one of the most important factors influencing the distribution of the marine vegetation in the region of Port Arthur is exposure.

On Kangaroo Island, South Australia, Womersley (1947) has found on steeply sloping exposed rocky coasts a *Rivularia-Isactis* association in the upper littoral and in the lower littoral a coralline-mat association sometimes with a small stout *Laurencia* and *Dasyopsis clavigera*. This passes into an association of the brown alga *Cystophora intermedia* occupying the sub-littoral fringe.

On sheltered rocky coasts there is described an upper littoral zone of blue-green algae and coralline-mat association often with other small red species and sometimes with a *Hormosira* association at a lower level. The upper sub-littoral zone is characterized by the dominance of species of *Cystophora*.

Near Sydney on the coast of New South Wales very exposed rocky shores may carry a seasonal band of *Porphyra* in the mid-littoral and the first distinct band of algae is one occurring in the lower littoral and made up of a variety of small species including *Corallina*, particularly in the upper parts, *Laurencia* sp., *Pterocladia capillacea*, *Zonaria* sp., stunted *Sargassum* sp., and other species, the composition varying with the environmental factors. This shrubby association extends into a band

of the ascidian *Pyura praeputialis* occupying the lowermost part of the littoral while in the sub-littoral fringe and upper sub-littoral there appear the large brown alga *Phyllospora comosa* often with *Ecklonia radiata* slightly lower.

On sheltered shores *Bostrychia mixta* and blue-green algae may occur in the upper littoral, particularly where shaded and the mid-littoral is frequently occupied by a band of the oyster *Saxostrea commercialis* bounded below by a dense band of *Galeolaria caespitosa* often associated with *Gelidium pusillum*. *Hormosira* appears just below the upper limit of *Galeolaria* and forms a band sometimes with *Corallina* in the lower littoral. *Ecklonia* appears densely in the sub-littoral fringe and upper sub-littoral and is often separated from the main band of *Hormosira* by a narrow strip occupied by a variety of small algae including *Corallina*, *Codium lucasii*, *Ceramium* sp., *Polysiphonia* sp., and others.

Dakin, Bennett and Pope (1948) describe the inter-tidal ecology of the New South Wales coast and give instructive diagrams showing the zonation on shores of varying exposure.

The general picture in both these localities though differing in some respects nevertheless has certain features in common with the inter-tidal picture at Port Arthur. In exposed positions both show a sparingly colonized upper and mid-littoral and the first permanent band of larger algae is a lower littoral one of small scrubby species in which *Corallina* plays an important part. The differences in this band in the various localities appear to be in the somewhat different proportions of the various constituents rather than in the essential nature of the band itself. At Kangaroo Island the *Corallina* seems to be exceptionally well developed at the expense of other species, while at Port Arthur the red species of the *Laurencia* association are developed at the expense of the *Corallina* which in the absence of competing species assumes much greater importance.

It is in the vegetation of the sub-littoral fringe that the more striking differences are seen. On Kangaroo Island *Xiphophora* is present in some places but it seems to appear below a band of Cystophora in the sub-littoral fringe and can hardly present the distinctive sharp band found at Port Arthur. Near Sydney *Xiphophora* is absent and its range is occupied by the *Pyura* and perhaps in part by the uppermost *Phyllospora*. But the really outstanding difference is in the occupation of the sub-littoral fringe near Sydney by *Phyllospora* and on Kangaroo Island by *Cystophora*, both in appearance very poor substitutes for the massive *Sarcophycus* of more southern latitudes.

Oliver (1923) describes in New Zealand associations of two small close growing algae *Bostrychia arbuscula* and *Caulacanthus spinellus* in the upper part of the intertidal belt. Associations of *Ulva rigida* and *Porphyra columbina* may occur at about half-tide mark while *Hormosira* with *Corallina*, best developed in harbours, forms an association sometimes completely covering the rocks in the lower part of the intertidal region. With it may occur also *Scytothamnus australis*, *Colpomenia sinuosa*. *Adenocystis utricularis*, and in shady places, *Codium adhaerena*. Towards low water mark the *Hormosira-Corallina* association is replaced by a thick low growth of *Stypocaulon*, *Ballia*, *Nitophyllum*, *Chaetomorpha* and other species.

The appearance of these sheltered shores with a lower littoral *Hormosira* band shows good agreement with the vegetation or similar shores at Port Arthur, but north of lat. 38° S. Oliver reports a well defined band of *Ostrea cucullata* centred about half-tide mark. Chapman (1950), Dellow (1950) and Carnahan (1952) all working on sheltered localities near Auckland report bands of *Saxostrea glomerata* and these bands probably give sheltered shores in the northern part of New Zealand an appearance rather more similar to sheltered shores near Sydney than to those at Port Arthur.

In exposed situations *Xiphophora* is described as occupying a belt inshore of the *Durvillea* association below which is a growth of *Marginaria boryana, Lessonia variegata, Carpophyllum maschalocarpum* and *Cystophora dumosa.* Beneath these the rock surface is completely covered with corallines and a number of small red and brown algae. Where *Durvillea* is absent *Xiphophora* seems to pass directly into a *Carpophyllum* association which occupies rocks exposed only at spring tides and extends below low tide mark for a little distance. This association is dominated by *Carpophyllum maschalocarpum* and depending on the locality there may occur also *Ecklonia richardsonia, Carpoglossum plumosum, Sargassum sinclairii, Cystophora dumosa* and *Marginaria boryana.* There is an undergrowth of smaller algae including *Pterocladia lucida, Melanthalia abscissa, Caulerpa sedoides, Zonaria turneriana* and others.

This picture presented by Oliver seems to correspond remarkably well with what is seen on semi-exposed and exposed shores at Port Arthur, and though species may differ, growth form is closely paralleled.

Cranwell and Moore (1938) give an account of the exposed shores of the Poor Knights Islands, New Zealand, and described seasonal societies of *Porphyra columbina* in the upper littoral while *Apophloea* is the dominant algal species in the mid-littoral. Algal members here are few but include *Porphyra, Nemastoma oligarthra,* N. sp., *Nemalion lubricum, Hildenbrandtia crouanii* and *Ralfsia* sp. Below this is generally a pink *Novasta* (a mollusc)—encrusting coralline association with some small red algae including *Nemalion, Laurencia virgata, Trematocarpus aciculare, Gigartina* spp., *Polysiphonia, Ceramium, Callophyllis* and *Ulva.* The region about low water neap tide is occupied by a band of *Xiphophora chondrophylla,* the junction with the *Novasta*—coralline belt appearing clear cut. *Xiphophora* is replaced by *Durvillea* in a few places on the Poor Knights where heavy surf runs, and below the *Xiphophora* is an association dominated by either *Carpoglossum elongatum* or *C. maschalocarpum.* In the sub-littoral the *Carpophyllum* is followed by a *Lessonia* association sometimes with an intervening community of red algae.

Again the picture of the exposed shore presents great similarity to the comparable shores at Port Arthur, the *Novasta*—coralline association with its small red algae in New Zealand being represented by the *Corallina* fringe, *Laurencia* association and encrusting coralline association at Port Arthur, while similar bands of *Xiphophora* in both areas are followed by *Phyllospora* in Tasmania and *Carpoglossum* in New Zealand. In the most exposed positions *Sarcophycus* and *Durvillea* form comparable associations and the main point of difference seems to be in the occurrence in the Poor Knights of a dominant algal species, *Apophyloea sinclairii,* in the mid-littoral, an association quite unrepresented at Port Arthur and elsewhere in Tasmania.

Beveridge and Chapman (1950) give an account of the intertidal communities at Piha, a locality on the west coast of the north island of New Zealand fully exposed to the full force of the prevailing westerly winds. *Bostrychia arbuscula* is dominant in the upper part of the littoral, *Porphyra columbina* occurs between mean high water springs and mean sea level, while the area between mean high water neaps and mean low water neaps seems fairly bare of algae though a number of small species including *Centroceras clavulatum, Gelidium pusillum, Apophloea sinclairii, Gigartina alveata, Gelidium caulacanthus* and others are stated to occur occasionally. Below mean sea level *Gigartina alveata, Pachymenia himantophora* and *Gigartina marginifera* each in turn become dominant, the last mentioned extending to mean low water spring tides. In exposed positions *Durvillea* may occupy the range extreme (lowest) high water mark neap tides to extreme low water springs, approximately the range occupied in positions less exposure by *Pachymenia himantophora* and *Gigartina marginifera.*

The main features of vegetation distinguishing this shore from similar areas at Port Arthur seem to be the absence of the *Xiphophora* band and the increased width of the band of scrubby red algae in the lower littoral, an increase which might be expected in the absence of *Xiphophora.*

Skottsberg (1941) describes *Hildenbrandtia* as forming thick, uneven, dark purple crusts in the uppermost littoral on exposed rocky shores in the Subantarctic. The *Bostrychietum* may extend almost as high up forming an intermediate *Hildenbrandtia-Bostrychia* association. With the *Bostrychia* may be found *Cladophora* spp., *Rhizoclonium riparium, Catenella fusiforme* and *Chaetangium fastigiatum* while in the lower part of the association *Phaeophyceae,* especially *Scytosiphon lomentaria* and *Caepidium antracticum* may become co-dominant, and a conspicuous association of *Porphyra umbilicalis* may occupy a middle littoral habitat. Species of *Iridaea* occur in the lower littoral and uppermost sub-littoral as a rule with a bottom layer of lithothamnia, while *Durvillea antarctica* and *Durvillea harveyi* belong to the lower littoral region in the most exposed places, the latter species extending to depths of 1-2 m. at low tide. The arborescent *Lessonia nigrescens* forms submarine forests from near low-water mark to a depth of several metres.

In sheltered situations also Skottsberg reports the *Bostrychia* and *Hildenbrandtia* associations but finds that *Iridaea obovata* seems to be confined to open situations. In the lower littoral regions small brown and green algae predominate and include *Adenocystis utricularis, Scytosiphon lomentaria,* species of *Cladophora* and *Monostroma,* and *Ceramium rubrum.*

Skottsberg has remarked on the resemblance between the littoral region of the subantarctic and that of New Zealand as described by Oliver and by Cranwell and Moore, and there seems also to be a clear resemblance between the regions of Port Arthur and the Subantarctic. *Bostrychia* and *Hildenbrandtia* are generally lacking on the exposed shores at Port Arthur but the *Porphyra* and *Scytosiphon* of the Subantarctic are both represented, and the *Laurencia* association may be compared with Skottsberg's band of *Iridaea* with its bottom layer of Lithothamnia. The species of *Durvillea* are clearly comparable with the *Sarcophycus* in Tasmania

but there seems to be no species in the Subantarctic representing the *Xiphophora* band in Tasmania and the range of this species is probably occupied in the Subantarctic in part by *Iridaea* and in part by *Durvillea antarctica*.

In sheltered localities the absence from the lower littoral of the *Hormosira* association so typical of Tasmanian shores must give the lower littoral region of the Subantarctic a rather different aspect.

Considering the accounts given by the various authors of the algal vegetation on the shores of Australia, New Zealand and the Subantarctic it seems that on exposed coasts the general appearance of the shore vegetation at Port Arthur has more in common with that of New Zealand and the Subantarctic than with shores near Sydney or on Kangaroo Island, the more marked resemblance to the former localities depending largely on the presence of *Xiphophora* and *Durvillea* in New Zealand and of *Durvillea* in the Subantarctic.

But in sheltered positions the common occurrence of *Hormosira* on the shores of New Zealand, Sydney and Kangaroo Island give these areas rather than the Subantarctic a considerable resemblance to Port Arthur shores. The common occurrence at Port Arthur of species of *Cystophora* in the sub-littoral fringe and upper sub-littoral heightens the affinity with Kangaroo Island.

Skottsberg has compared shores in the Subantarctic with those in the Northern Hemisphere and has been able to refer some of the Subantarctic associations to corresponding associations composed of other species in the Northern Hemisphere. He finds that *Hildenbrandtia*, *Bostrychia* and *Porphyra* are all represented by comparable associations on the west coast of North America and the first two also in the North Atlantic. The *Durvillea antarctica* of the Subantarctic is paralled by *Postelsia* on the west coast of North America and by *Alaria* and *Laminaria* in the North Atlantic.

The great and striking differences between these two regions become apparent on the sheltered shores which in northern Europe and to a less extent in the North Pacific are bounded from almost high to low water mark by members of the Fucaceae, and Skottsberg remarks that "It is the total absence of *Fucus* and allied genera that makes the Subantarctic littoral look to be utterly different from the Subarctic. The undergrowth of small brown, green and a few red algae is all that remains . . ." In Tasmania, *Hormosira* probably in part corresponds to *Fucus serratus* in the North Atlantic, but apart from this, Skottsberg's remarks might just as well be applied to Tasmanian shores.

Isaac (1937, 1949), working on the west and south coasts of South Africa, has found above the lower littoral zones of red algae a bare zone which is relieved only by a zone of *Porphyra* on the south coast and by zones of *Porphyra* and *Chaetanguim* on the east coast.

It thus seems that the comparative paucity of fleshy algae, particularly Phaeophyceae, in the mid- and upper littoral regions is generally characteristic of shores in the Southern Hemisphere. The bareness of the Australian intertidal region has been noted by Newton and Cribb (1951) and it has been suggested that light intensity, temperature, and desiccation may be among the factors responsible for the differences noted. The

effect of these factors would certainly be expected to increase with nearness to the Tropics, so that their effect in Queensland and New South Wales would be greater than in Tasmania. If they were the only operative factors, however, a rich littoral vegetation of Phaeophycean species would be expected to have developed in the Subantarctic. Not only is this not so, but the two uppermost bands of fleshy Phacophyceans found on the Tasmanian coast, namely, *Hormosira* and *Xiphophora*, are actually absent from Subantarctic shores and are unreplaced by any comparable species. So whatever the reasons for this littoral bareness in more southerly latitudes may be, it seems unlikely that insolation, temperature and dessication are the prime factors over the whole of the area concerned.

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Plate 1.—Semi-exposed to exposed rocky shore carrying a band of white lichens in the supra-littoral and a band of *Lichina confinis* in the upper littoral.

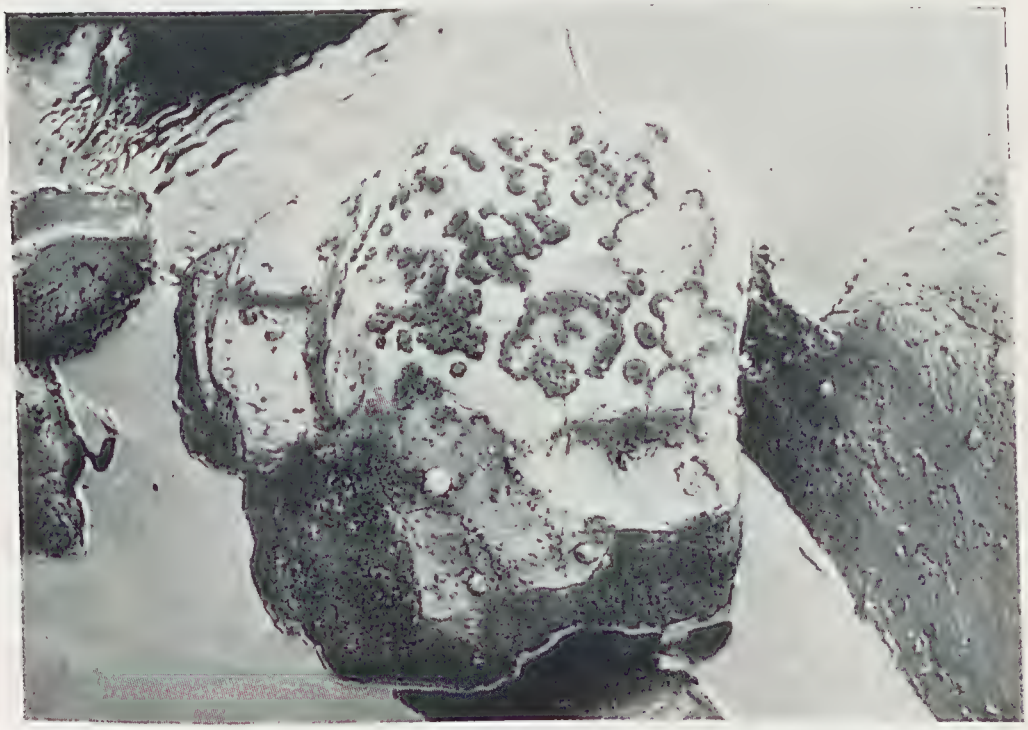

Plate 2.—Well developed colonies of *Lichina confinis* on a sheltered boulder.

Plate 3.—*Galeolaria caespitosa* and *Hormosira banksii* on mudstone in a sheltered locality.

Plate 4.—*Galeolaria caespitosa* and *Mytilus planulatus* succeeded downshore by bands of *Hormosira banksii*, *Cystophora torulosa* and *C. cephalornithos* respectively.

Plate 5.—Vertical side of a mudstone platform carrying a narrow dark coloured band of *Laurencia botryoides* and other Rhodophytes above a wider band of *Xiphophora billardieri*.

Plate 6.—Exposed rocky shore carrying a mid-littoral band of *Porphyra umbilicalis* with *Sarcophycus potatorum* in the sub-littoral fringe.

PLATE 7.—*Sarcophycus potatorum* exposed between surges on the margin of a mudstone platform.

PLATE 8.—Cushion-shaped colonies of *Lithophyllum hyperellum f. fastigiata* mingling with barnacles and limpets above small plants of *Sarcophycus potatorum*.

Plate 9.—A bed of *Macrocystis pyrifera* fringing laminated mudstone cliffs and pavements.

Plate 10.—A sand-mud flat with *Zostera tasmanica* partly exposed at low tide. *Hormosira banksii* is developed on rocks in the foreground.

A New Bothid Fish from Eastern Tasmania

By

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WITH 1 PLATE

Summary

Arnoglossus andrewsi, sp. nov. is described and characters by which it can be distinguished from *Arnoglossus bassensis*, Norman, are listed.

Introduction

During the winter of 1952 a newly-found scallop bed in Oyster Bay on Tasmania's east coast was fished commercially for the first time. Mr. E. E. Andrews, Chief Inspector of Fisheries for Tasmania, whilst examining material brought up in the dredges noticed a small flat fish of unusual appearance which he preserved and sent to the author for identification. It was suspected that the specimen belonged to an undescribed species and as the fish was immature, efforts were made to obtain more. Several larger specimens were taken subsequently, but they were extensively damaged by the dredge and it was not until the following year that the series of seven fish used in the following description was obtained. Shortly afterwards another specimen was collected in George's Bay, near St. Helens.

All fish were taken in depths of seven or eight fathoms on weed and sponge bottom and it is of interest to note that, although the same type of fishing gear has been used for several decades in D'Entrecasteaux Channel, the species has never been reported from that area.

It is proposed to lodge the holotype with the British Museum of Natural History and the paratypes with Australian Museums.

Description of Holotype

Family BOTHIDAE

Subfamily *BOTHINAE*

Genus **Arnoglossus** Bleeker, 1862

Arnoglossus andrewsi sp. nov.

Dorsal profile of the head evenly curved, notched opposite the centre of the upper eye. Snout a little longer than the eye. Eyes may be level or the lower a little in advance of the upper which is separated from the upper edge of the head by a space equal to one-third its diameter. The eyes, which are set close together, are separated by a prominent bony

ridge. Maxillary, whose upper posterior margin is angular, extends to below anterior third of lower eye. When mouth is closed, lower jaw is level with upper. Teeth uniserial, anterior ones largest and well separated. Some teeth on the ocular side of the jaw movable. Gill rakers short and blunt with inner edges spinulate. Scales of ocular side ctenoid, those of blind side cycloid. The lateral line is well developed and has no accessory branch. All rays in the dorsal fin are simple and scaled on both sides. The first dorsal ray is inserted slightly on the blind side opposite to or a little in front of the anterior nostril of that side. The first ray of the anal fin is inserted level with or a little in front of the posterior margin of the operculum. The left pectoral is in line with the lower eye and the insertion of the posterior anal ray. It is generally greater in length than that of the right side. The anterior ray of the left pelvic is situated behind the posterior margin of the upper eye. The first ray of the right pelvic is opposite the third ray of the left. Caudal fin rounded with a short peduncle.

Colour of dead but freshly dredged specimens pinkish brown with irregular dark blotches and spots on body and fins. There are two conspicuous blotches on the lateral line, one immediately behind the arch and the other approximately half the distance between this and the caudal peduncle. An additional prominent blotch lies just below the pectoral fin. Except for a small area around the pelvic fin in some specimens, the blind side is unpigmented.

The variations in morphological characters found in the series of seven specimens together with the corresponding features of the holotype are given in Table 1.

TABLE 1

Character	6 Paratypes	Holotype
Total length in mm.	28-213	175
Depth of body in standard length	2·3-2·4	2·3
Length of eye in head length	5·0-5·4	5·0
Length of maxillary in head length	2·7	2·7
Number of gill-rakers on lower half of anterior arch	6-7	6
Number of lateral line scales	91-95	94
Height of lateral line arch in length of same	2·5-3·5	2·5
Length of head in standard length	2·4-4·4	4·2
Length of left pectoral in head length	1·7-2·1	1·7
Length of caudal in head length	1·1-1·3	1·2
Depth of caudal peduncle in head length	1·9-2·2	1·9
Number of dorsal rays	90-94	93
Number of anal rays	71-74	73
Number of left pectoral rays	10	10
Number of caudal rays	2/13/2	2/13/2

Discussion

When first examined *Arnoglossus andrewsi* sp. nov. appeared to be either very closely related to or identical with *A. bassensis, Norman* (1926). However, examination of a specimen of the latter, kindly lent by the Australian Museum confirms the view that the differences between it and the specimens to hand, are specific. These differences comprise four meristic characters, the shape of the caudal fin and the nature of the scales. In every case the scales on the ocular side of *A. andrewsi* are larger and distinctly ctenoid. They differ in shape and structure from the cycloid scales found on that side in *A. bassensis.*

The characters by which *A. andrewsi* can be distinguished from *A. bassensis* are given in Table 2.

TABLE 2

Character	*Arnoglossus bassensis*	*Arnoglossus andrewsi* sp. nov.
Number of dorsal fin-rays	98-99	90-94
Number of anal fin-rays	77-78	71-74
Number of gill-rakers	7-9	6-7
Nature of scales on ocular side	cycloid	ctenoid
Shape of caudal fin	obtusely pointed	rounded

Acknowledgments

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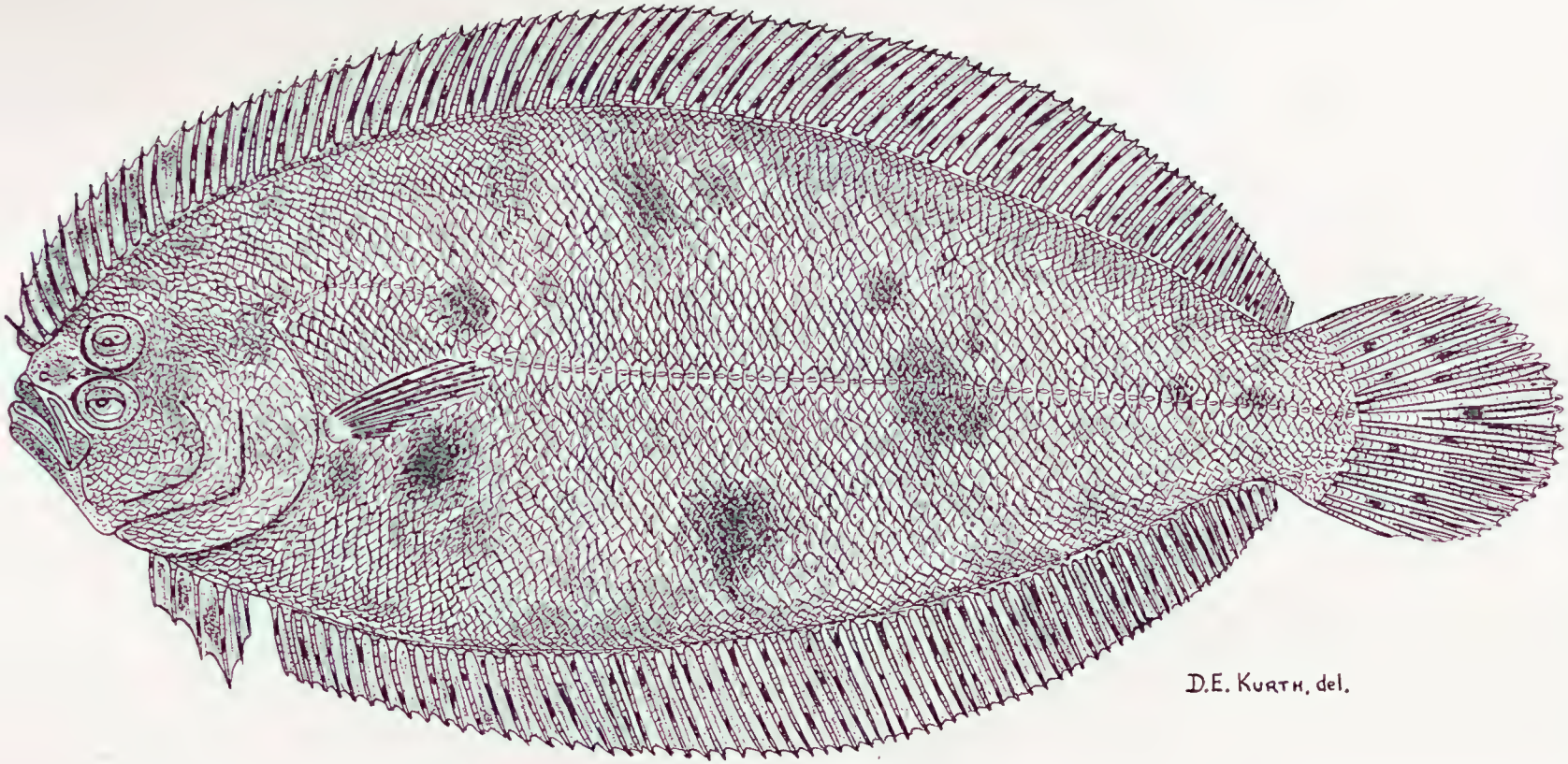

ARNOGLOSSUS ANDREWSI sp. nov.

Holotype of *Arnoglossus andrewsi* sp. nov. viewed from left side.

Papers and Proceedings of the Royal Society of Tasmania, Volume 88

The Recolonization of Rock Surfaces and the Problem of Succession

By

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WITH 6 PLATES AND 2 TEXT FIGURES

Summary

The colonization of new rock surfaces was observed experimentally as well as the recolonization of artificially denuded rock surfaces. Although in both cases the initial settlement of the larvae was successful there was a heavy mortality soon afterwards with a consequently slow rate of recolonization. This was attributed to environmental factors. It is seen that recolonization of rocks after natural denudation is very much more rapid. Seasonal number growths of *Porphyra*, *Scytosiphon* and *Ulva* are recorded.

Introduction

Small scale experiments were carried out in an attempt to ascertain the sequence of colonization of bare rocky surfaces on the shore in the region of Pinnacle Point at the south end of Blackman's Bay. Blackman's Bay was chosen as the area in which to conduct the experiments because it could be visited at frequent intervals, is easy of access and its fauna is reasonably well known.

In order to throw some light on the poverty of the fauna of the Midlittoral zone the original experiments were carried out in the lower part of the barnacle and the upper part of the *Galeolaria* belts. Later experiments were commenced in the *Mytilus* belt. Due to circumstances beyond my control, both series of experiments were inconclusive but certain interesting results were found.

Literature

Work has been carried out in various parts of the world on the problems of intertidal colonization. In some cases the workers have been concerned with the colonization of new rock surfaces and in others the emphasis has been placed on the recolonization of denuded rock surfaces. In Britain, Kitching (1937) and Pyefinch (1943) have been concerned with the latter aspect. In France, Fischer-Piette (1929 and 1932B), Hatton and Fischer-Piette (1932) and Hatton (1932) have studied the general aspects of the problem. Much work has been done in America on the season of attachment of sedentary marine organisms and their rates of growth. Among the American authors whose work bears on the recolonization problem are Visscher (1928), Visscher and Luce (1928), Pierron and Huang (1926), Coe (1932), Graham and Gay (1945) and Wilson (1925).

The colonization of new surfaces has been studied by several European workers. In many instances advantage has been taken of

public works to supply the new surfaces. Brandt (1897) studied the colonization of the Kiel Canal, Herpin (1935A and 1935B) observed the colonization of beaches and wrecked ships and Rees (1940) noted the succession of a new sewage outfall. Moore (1939) and Moore and Sproston (1940) described the sequence of colonization of a new sea-wall at Plymouth.

There has been very little work done in Australia on this aspect of intertidal ecology. Some experiments on fouling have been described by Wood (1950) and have some bearing on the intertidal problem.

(a) Colonization of bare rock surfaces

Method

Two rocks were chosen for the experiment. One was of dolerite and the other of mudstone. Both had to be of sufficient weight to remain stationary under conditions of the most intense wave action experienced in the site chosen. The rocks were cubes with sides approximately one foot long.

The rocks were examined ten times over a nine-month period. Each face of the rock was examined in detail and the results of these examinations were plotted on full size, or half size, reproductions of the faces of the rock. This simplified identification of previously recognized individuals.

In order to avoid crushing any forms dwelling on the bottom surface of the rocks a smaller rock was utilised for bottom surface examinations. This smaller rock was placed beside the larger rocks and only the fauna on the under side of it was examined. The rock was placed in such a position that the under surface of it was free from the substratum.

The experiment would have been continued for a longer period than nine months, if it had not been for the fact that the rocks were thrown into deep water by some unknown persons. I do not consider that wave action was responsible for the loss as during the period the rocks disappeared there were no gales of greater severity than had already been experienced.

The site selected was in a channel on the north side of the platform at Pinnacle Point at the south end of Blackman's Bay. The channel is completely uncovered at "low low" tide and has a varied and numerous population. Wave action is not strong, the maximum being a (1-7) 1, b2. Under certain conditions of bad weather heavy surf crashing across the platform pours into the channel but the force is mostly spent by the time it reaches the channel and the rock is only subjected to a cataract of water.

The channel was inhabited by *Hymeniacidon perlevis* (Montagu), *Actinia tenebrosa* (Farq.), *Elminius modestus* Darwin, *Chthamalus antennatus* Darwin, *Ibla quadrivalvis* (Cuvier), *Corallina* sps., *Hormosira banksii* (Lam.), Decaisne, *Amaurochiton glaucus* (Gray), *Patelloida conoidea* (Reeve), and *Galeolaria caespitosa* (Lam.).

Description of the Rocks Selected

It was originally intended to use rocks of dolerite and mudstone in different parts of the shore but pressure of other work restricted the experiment to the one site with two rock types. The rocks were put in position simultaneously, but the mudstone rock only remained in position for three weeks and then vanished. The rock was not replaced as strictly comparable results could not be obtained with a rock placed in position at a later date. The value of the experiment is not very great but it is included here as several points of interest are raised by the colonization processes.

The dolerite rock was selected from a pile of this rock lying above high water mark on the beach at Sandy Bay. The rock was removed to the laboratory and thoroughly scrubbed with hot water. Chemicals were avoided in this process to avoid reactions with the minerals of the rock. The rock was left to weather for a few weeks after which it was put in position. The smaller rock for the bottom surface experiments was similarly treated. The larger rock was known as Winter Rock A and the smaller as Winter Rock B.

The nature of the rock faces and their orientation can be best expressed in Table 1.

TABLE 1

Nature, orientation and area of the faces of Winter Rocks A and B.

Smooth, sea-sheltered vertical face with vertical and inclined ridges	Landward, 419 sq. cms.
Smooth, sea-exposed vertical face with exposed vertical and inclined ridges	Seaward, 494 sq. cms.
Semi-exposed vertical face with inclined and vertical ridges	Left hand, 637 sq. cms. Right hand, 708 sq. cms.
Sea and air-sheltered horizontal face with lateral ridges	Bottom, 271 sq. cms.
Sea and air-exposed horizontal face with lateral ridges	Top, 432 sq. cms.

The experiment was commenced on 18th April, 1948, and observations were made on 1st May, 12th May, 19th May, 29th May, 20th June, 26th June, 3rd July, 8th July, 15th July, 21st July, 14th August, 29th August, 21st September, 19th October, 3rd December, 10th January, 15th February. On the latter date only, the bottom face of Winter Rock B was examined. Winter Rock B is still in position at the time of writing (October, 1953) and it has been examined frequently since 15th February, 1949.

The first sessile organism to appear on the rocks was a small *Corallina* sp. on the landward face in May. Previous to this several errant species were seen on the faces of the rock, notably *Amaurochiton glaucus*, *Patiriella exigua* (Lam.), *Cominella lineolata* (Lam.) while below the rocks crabs (*? Petrolisthes* sp.) were sheltering. Amphipods were found in cracks on the rock. The first occasion on which large numbers of colonizing animals were noted was in June when 113 individuals appeared on the rocks. There were only nine deaths noted during this period.

Of these new individuals over 72 per cent were *Galeolaria*. These tubes were not confined to the lower part of the rock. About 25 per cent of them were found on the top surface. Barnacles appeared at the same time as the worms but in fewer numbers. A colonial diatom association, mainly of *Euschizonema* and *Melosira* sps. appeared at this time. These colonies were of a very short lived nature only, two extending from one week to the next. These diatoms are discussed below.

There were no macroscopic forms other than barnacles, *Galeolaria* and *Corallina* to successfully colonize the rock. *Actinia tenebrosa, Patelloida conoidea* and two errant annelids appeared but soon wandered away again. There was a constantly changing number of *Amaurochiton glaucus* on the rock. Several of these were marked and one was noted as returning to the rock at 2, 5 and 3 week intervals.

Table 2 shows the number of new individuals settling each month and the number of deaths per month on each of the faces of the rocks. Although during certain months the rock was visited more frequently than others, thus giving a greater number of new settlements, there is no doubt that some faces of the rock were more densely populated during some months than others. The figures, although they show an overall increase of deaths and settlements during the more frequently visited months, reflect the true picture of the trends by the ratio of these numbers.

TABLE 2

The new settlings per month on each face of Winter Rocks A and B.

	MAY		JUNE		JULY		AUGUST	
	Settlings	Deaths	Settlings	Deaths	Settlings	Deaths	Settlings	Deaths
Top	1	....	23	....	38	33	2	26
Seaward face	....	....	7	....	14	12	2	5
Landward face	1	....	1	2	26	10	4	18
Right-hand face ..	....	....	9	....	52	14	14	39
Left-hand face ..	....	....	31	....	11	37	2	6
Bottom	....	....	42	7	51	29	7	37

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	Settlings	Deaths	Settlings	Deaths	Settlings	Deaths	Settlings	Deaths
Top	5	1	4	4	?	?	....	4
Seaward face	3	....	4	5	?	?	19	6
Landward face	2	....	5	1	?	?	2	6
Right-hand face ..	19	6	15	15	?	?	11	19
Left-hand face ..	2	0	3	3	?	?	1	2
Bottom	7	6	33	6	?	?	8	36

	JANUARY		FEBRUARY	
	Settlings	Deaths	Settlings	Deaths
Bottom	5	13	8	6

Table 3 and Fig. 1 show the total number of individuals inhabiting the faces each month, while Table 4 and Fig. 2 show the new settlings and deaths of the various species per month.

From these tables and graphs it can be seen that there is a very great decrease in the total number of organisms on all faces between July 21st and August 14th and also between October and December. If the trends shown by the bottom face of Winter Rock B are true, there is also a sharp diminution of numbers in December and January.

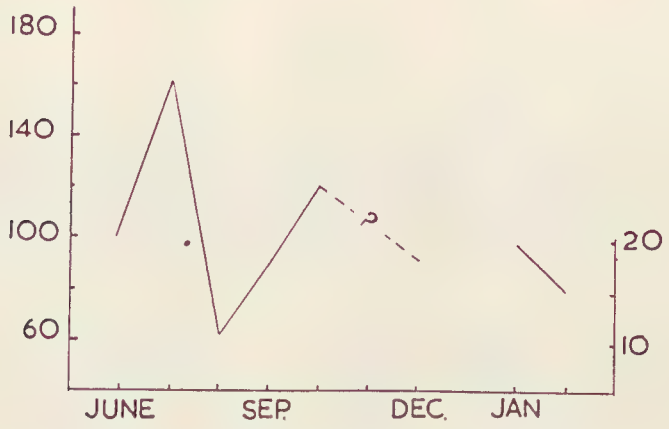

FIG. 1.—The total number of individuals inhabiting all faces of Winter Rocks A and B from June, 1948, to February, 1949.

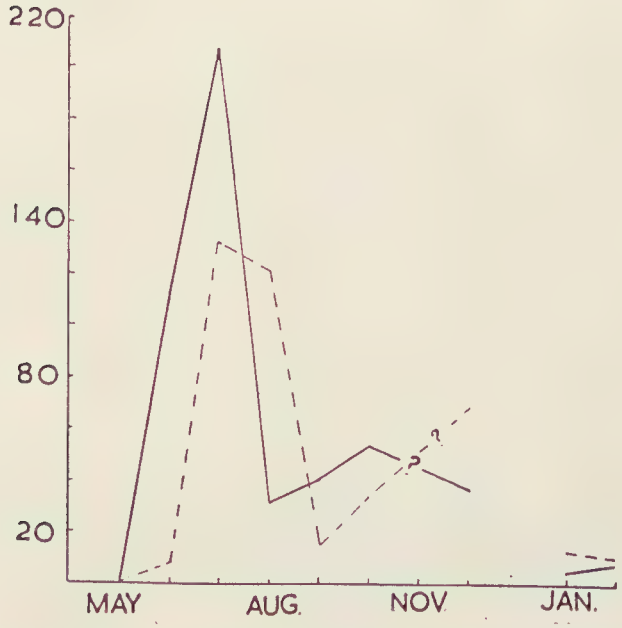

FIG. 2.—The number of settlements and of deaths (broken line) per month on all faces of Winter Rocks A and B.

TABLE 3

The total number of individuals of all species inhabiting the various faces of Winter Rocks A and B each month for the period June, 1948, to December, 1948.

	June	July	August	September	October	November	December	Totals
Top	23	27	3	7	7	?	3	70
Seaward face	....	9	6	9	8	?	21	53
Landward face	1	16	2	4	8	?	4	35
Right-hand face	9	47	22	35	37	?	27	177
Left-hand face	31	5	1	3	3	?	4	47
Bottom	35	57	27	28	55	?	27	229
Grand Totals	99	161	61	86	118	?	86	611

The bottom face only during January and February had 19 and 16 inhabitants respectively giving an absolute total of 646 organisms noted. These latter figures are not included in the table as they are only indications and may not be true records of actual population changes.

TABLE 4

Total number of specific settlements and deaths per month.

Settlements	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Barnacles	....	18	57	16	24	33	?	24	2	3	177
Serpulids	....	81	130	12	11	14	?	1	3	3	255
Anemones	....	1	....	1	....	....	?	2	....	....	4
Diatoms	....	10	17	2	....	....	?	....	....	....	29
P. alticostata	....	....	....	....	1	3	?	....	....	....	4
P. conoidea	....	....	....	....	....	1	?	3	....	....	4
Patella ustulata	....	....	....	....	....	....	?	1	....	....	1
Corallina	1	2	....	....	....	....	?	6	....	....	9
Nereids	....	1	2	....	....	....	?	....	....	....	3
Red algae	....	....	1	....	....	....	?	....	....	....	1
Chiton eggs	....	....	....	....	3	....	?	....	....	....	3
Totals	1	113	207	31	39	52	?	36	5	6	490

Deaths	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Barnacles	....	3	13	26	1	10	?	45	13	7	118
Serpulids	....	3	94	90	13	19	?	18	....	1	238
Anemones	....	1	....	....	1	....	?	....	....	....	2
Diatoms	....	1	23	5	....	....	?	....	....	....	29
P. alticostata	....	....	....	....	....	....	?	3	....	....	3
P. conoidea	....	....	....	....	....	....	?	1	....	....	1
Patella ustulata	....	....	....	....	....	....	?	1	....	....	1
Corallina	....	1	....	....	....	....	?	....	....	....	1
Nereids	....	....	2	....	....	....	?	....	....	....	2
Red algae	....	....	1	....	....	....	?	....	....	....	1
Chiton eggs	....	....	....	....	....	3	?	....	....	....	3
Totals	....	9	133	121	15	32	?	68	13	8	399

The number of forms successfully settling also shows a sharp diminution in August and January. The number of deaths in July and August is very high. The large number of settlings in July possibly came from a late autumn spawning.

The seaward and landward faces of the rock never had as dense a population as the other faces.

The total population of the bottom face of Winter Rock B is still low (October, 1953), consisting of 18 occupied *Galeolaria* tubes, 22 *Chthamalus antennatus* and 12 *Chamaesipho columna* as well as a patch, 5 cms. by 3 cms. of *Hymeniacidon perlevis*. Numerous errant types dwell on the surface. Plate I shows the rock after $3\frac{1}{2}$ years.

Discussion

From the above observations it can be seen that the rate of successful colonizing is very slow compared with the rate in other parts of the world where there is a much greater density of population per unit of time. It is proposed to examine some of the factors which may influence the settling of larvae on the experimental rocks.

There is a close correlation between the critical months for intertidal organisms as deduced from physical data in an earlier paper (Guiler, 1950) and the observed rates of settling and deaths on the experimental rocks. December, January and July are considered to be critical months for intertidal organisms due to the combination of adverse tidal and meteorological factors. April and October are regarded as months of slightly less strain due to the equinoctial change of tidal behaviour. From Tables 2, 3 and 4 it can be seen that there are times of high casualties and low spatfall between late July and early August and in October and December. It is further indicated by Winter Rock B (Tables 2 to 4) that January is also a month of stress, though this is not conclusive. March and April unfortunately are not included in the experiment for the reasons given above.

The black colour of the rock would certainly assist barnacle settling. The larvae being negatively phototropic (Visscher, 1928) would choose a dark surface in preference to the surrounding lighter coloured mudstone. The relative absence of surf would tend to reduce the number of successful barnacle settlings though it has been shown by Coe (1932) that test blocks exposed to heavy surf were cleared of barnacles measuring up to several millimeters in diameter. In the channel in which the experimental rocks were situated there was not nearly as great a barnacle population as there was on the exposed edge of the rocky platform. On the other hand, the seaward face of Winter Rock A which would experience whatever wave action there might be, had very few barnacles on it, having very much smaller number than either of the lateral faces. In general, it might be concluded that the channel was not very highly suited to barnacle life, though barnacles were living there.

The poverty of barnacles on the seaward face of Winter Rock A is possibly explained by the fact that the face was towards the North, i.e., it was exposed to the sun. This would drive cyprid larvae round to the sides of the rock where they would find more congenial conditions. Any larvae which had settled on the seaward face would probably be killed by the sun before the metamorphosis was complete. The right hand face, because it is sheltered from all but the early morning sun, has a comparatively rich fauna.

It has been shown by Hopkins (1935) that oysters tend to form their densest colonies on the under surface of objects. The reason for this lies in the larval method of swimming with the velum upwards. There is little evidence of this behaviour being shown by any of the larval forms encountered during the experiment.

It has been noted by Coe (1932) that the degrees of roughness of surfaces influences the population inhabiting them. In this case the faces of the rock were all of equal smoothness and the factor is not applicable to the fauna of different rock faces.

The absence of any algal grazers permanently dwelling on the rocks points to the fact that an algal film was not formed on the rock. This may have been influenced by bacteriological factors (Zobell and Allen, 1935). Wood (1950) found that bacteria do not play the role of forming the primary film but are replaced by algal spores.

The failure of organisms to colonize the rocks is due to the integration of a number of factors. The orientation and sitting of the rock and the relation of the faces to sun and wave exposure play some part. The lack of full wave action would reduce the number of barnacle settlements but ought to increase the number of *Galeolaria* settlements. The number of settlings by the worms was large but the death rate was also high. The high death rate was caused by the larvae settling in June or July and being unable to become established before the critical month of July.

Barnacle larvae settled throughout the year, though the critical months also caused a high death rate in these species. This is in contrast to the situation described by Moore (1939). In no sense was a pioneer community established as described by Rees (1940). The nearest parallel to colonization in South Tasmania is that described by Pyefinch (1943) who found that no inter-specific competition existed.

It can be concluded that the rate of settlement was very slow, Rock B being relatively unpopulated after 5½ years.

(b) The recolonization of depopulated rock in the *Mytilus* belt

The object of the experiment was to determine the sequence of recolonization of depopulated mussel beds. Six areas of rock, each area being one foot square, were scraped clean. The areas were in the mussel beds at Blackman's Bay on the platform at the Pinnacle. The areas are as shown in Table 5 and their distribution on the platform was selected so as to include different amounts of wave action.

TABLE 5

The experimental areas at Blackman's Bay.

Area 1. In the *Mytilus* beds on the surface of a shelf at the seaward end of the platform.
Area 2. In the mussel beds at a slightly higher level and further inshore than Area 1.
Area 3. On the vertical face of a cleft which is occupied by *Mytilus* and is exposed to wave action.

Area 4. On the surface of the platform to the south of Area 3.
Area 5. In the mussel beds on a low level shelf at the southern end of the platform.
Area 6. On the under-surface of a cleft near the southern end of the platform. The mussels in this instance are *Brachyodontes rostratus*.

The areas chosen are on both wave exposed and wave sheltered parts of the same restricted area of coast.

Method

The areas were cleared on the 16th October, 1950. The mussels and other loosely attached organisms were pulled off the rocks, barnacles, *Galeolaria* and other firmly attached animals were removed by scraping with a chisel, without damaging the surface of the rock. Each area formed a square of sides one foot in length. It was not found necessary to wash the rock as waves were continually sweeping over the platform. Visits were made to the areas at intervals and the forms inhabiting the areas were noted. The individual animal or plant found on the rock was not removed, but identification was carried out in the field, or by the collection of an identical specimen from near-by. This was done to avoid de-populating the experimental areas.

It was not always possible to make a detailed survey of the areas. High tides during the winter and the prevalent southerly swell prevented an examination of the areas on several visits. On other occasions only a partial examination was possible. Successful or partially successful examinations were carried out on 8th November, 1950, 20th November, 1950, 27th November, 1950, 8th January, 1951, 31st January, 1951, 8th March, 1951, 29th March, 1951, 10th April, 1951, 12th May, 1951, 23rd June, 1951, 15th August, 1951, 17th September, 1951, 23rd October, 1951, 30th October, 1951, and the 7th November, 1951. During the latter part of October a very strong gale caused heavy damage on the western shores of the estuary. This gale completely denuded the rocks of all attached animals and most of the plants.

16*th October*, 1950

The areas were cleared on this date and the fauna of the mussel beds was examined and found to be the same as that noted in Guiler (1950). The mussels were covered by a fairly thick growth of *Ulva lactuca*. On Area 6 there was no *Ulva* and the fauna was different from that in the other mussel beds. As noted in Table 5 the mussels inhabiting this cleft are *Brachyodontes rostratus* (Dunker). This bed of this species does not support a large cryptofauna as do the *Mytilus* beds. The only other species found on the *Brachyodontes* beds were *Elminius modestus, Chthamalus antennatus, Chamaesipho columna* and *Actinia tenebrosa*. These species were all utilising the mussels as a substratum and were found in a similar habitat on all the other areas.

8th November, 1950

There were no attached organisms to be found in the areas. Some small *Ulva* plants occurred on Areas 1, 2 and 5. Several roving species were found on Areas 1 and 5. These were *Sypharochiton pellis-serpentis* (Quoy & Gaim.), *Patelloida conoidea* and *Fossarina petterdi* Crosse.

16th November, 1951

Roving species were found on all of the areas, except No. 6. A few sedentary or attached species were present. One small *Ulva* plant occurred in Area 2. Area 5 was nearly permanently waterlogged due partly to the conformation of the rock and also to the very thick growth of *Ulva* and mussels on the shelf.

There was no evidence of any settlement on Area 6.

20th November, 1950

The early stages of the colonization were marked by the spreading of *Ulva* from the mussels on to the areas and also by the invasions of roving species. All areas, except No. 6, showed more or less growth of *Ulva*. Area 5 was densely covered by a *Polysiphonia* sp. This weed was only common in places where the mussels had been scraped off the rocks. Area 4 was partially colonized by the same seaweed.

The roving species encountered were *Cominella lineolata, Sypharochiton pellis-serpentis, Patelloida conoidea, Cellana variegata* and *Fossarina petterdi.* The latter species was very numerous on Area 2 where 10 individuals were counted. *Cominella lineolata* was rare, only one individual being noted. Area 3 was largely populated by limpets, while Area 3 was occupied by only one chiton.

The sessile forms which appeared were in the minority and were confined to Areas 2, 4 and 5. All these areas carried a few small mussels of about half an inch in length, though on Area 5 the mussels were nearly one inch in length. *Chthamalus antennatus* was found on Areas 2 and 4. There were a large number of *Galeolaria* tubes on Area 5.

27th November, 1950

It was not possible to examine Areas 1 and 5 due to a ground swell which was breaking on the platforms. During the week since the last examination there had been a small barnacle spatfall. Barnacles, *Elminius modestus,* were found on Areas 2 and 4. Also on Area 4 were several small *Chthamalus antennatus.* All these barnacles had disappeared by the next examination of the areas.

It was very noticeable that the roving species were not as numerous on this date as on the previous visits. One specimen of *Patelloida conoidea* was found on Area 4 and two individuals of the same species were found on Area 3. There were no other roving species found on any of the areas.

One small mussel, *Mytilus planulatus,* was recorded on Area 4 with several *Ulva* plants. The only other sessile forms found on any other area, with the exception of the barnacles mentioned above were some *Lithothamnion* on Area 3. The growth of this alga commenced very slowly but after a few weeks the species spread quite rapidly.

8*th January*, 1951

The effect of the hot summer weather was becoming noticeable in the very sharp diminution in the number of algae found on the areas situated on the higher parts of the shore. Area 2 had only one *Ulva* plant growing on it, though this plant was still healthy. The areas at lower tidal levels were still dominated by algae. Areas 1 and 4 both had considerable growths of *Ulva* and *Polysiphonia*, though some of the *Ulva* was in poor condition. *Polysiphonia* was dominant on Area 5 which was also richly covered with *Ulva*. On Area 1 the *Ulva* plants were very much dried and tended to tear away when they were gently lifted.

Animal colonization was becoming more rapid. It was not possible to make a detailed survey of Area 1 because of a dangerous ground swell, but Area 2 had 17 small *Mytilus planulatus*, each greater than a quarter inch but less than half an inch in length. Also living on Area 2 were 25 small *Elminius modestus* and two tiny *Corallina* plants. Area 3 was not a densely colonized area, being occupied by two small *Chthamalus*. Three *Mytilus planulatus* were living on Area 5. The largest of these was about one and a quarter inches in length. Area 6 was colonized by two small *Mytilus planulatus*.

The most interesting feature was noted on Area 4 where the large mussels forming the surrounding beds were beginning to encroach on the cleared patch. The encroachment was beginning from the southern edge of the area. The importance of this encroachment was seen in subsequent examinations. The removal of mussels to form a cleared area had an interesting effect on the mussel beds surrounding Area 3, where the sea had exploited the weakening of the mussel bed. This weakening led to the denudation of a small area of rock around the experimental area.

The number of roving species found on the areas had also increased considerably. *Sypharochiton pellis-serpentis* was found on all areas except No. 6, *Fossarina petterdi* was found on Areas 2, 3 and 4, *Siphonaria zonata* on Areas 3 and 4 and *Cominella lineolata* on Area 4. *Cominella* was locally very plentiful in the cleft in which Area 4 was situated.

31*st January*, 1951

Most of the *Ulva* which covered the mussel beds in early January had died since the last visit, but, surprisingly, there was a number of these plants growing on and around Areas 2 and 5.

The small *Mytilus* found previously had nearly all died, only one specimen being found (Area 2) but a number of *Galeolaria* tubes appeared on this area. The roving species were still numerous. *Patelloida marmorata* was noted for the first time, appearing in Area 2. The only area which showed any increase in animal population was No. 6 where 12 small *Mytilus planulatus* were noted. The mussels surrounding this area were all *Brachyodontes rostratus*.

The encroachment on to the experimental areas by the mussels was slowly proceeding.

In general, there was a very sharp reduction in the number of plants and animals colonizing the areas, but the encroachment on to the areas by the mussel beds was slowly proceeding.

8th March, 1951

Ulva had spread across the mussel beds and covered all the areas except No. 6. There had been a very large barnacle spatfall on Areas 1 and 5. There was little change in the mussel population on any of the areas. One large *Actinia tenebrosa* was found on Area 6. The specimen was too large to have settled as a juvenile and must have migrated on to the area.

The barnacles were all *Chthamalus antennatus* and were found packed together in small clusters on Areas 1 and 5. The barnacles numbered over two hundred on each area. It was not possible to undertake a detailed count because of the water washing over the areas.

Area 4 had been colonized by a large *Galeolaria* spatfall. The worm tubes were not as gregarious in their distribution as the barnacles and were distributed more evenly over the area.

28th March, 1951

Algae were dominant on all areas except No. 6. There were only two species of seaweed, namely *Ulva lactuca* and a *Polysiphonia* sp. *Ulva* was the more common of these species and it was dominant on all of the colonized areas except No. 1.

The large barnacle spatfall which was noted in February and early March had ceased and most of the young barnacles had died. On Area 4 only one small *Elminius modestus* was noted, though there were 12 mussels on the area. The *Galeolaria* tubes were still very numerous on this area.

Roving organisms were becoming more abundant. *Cellana limbata, Siphonaria zonata, S. diemenensis* (dominant animal on Area 2), *Amaurochiton glaucus, Patelloida alticostata* and *Fossarina petterdi* were found on the areas. Area 6 was dominated by *Mytilus planulatus* although this species was not numerous.

10th *April,* 1951

On this date it was not found possible to examine Areas 1, 3, 5 and 6 due to the high tides. The very high level of the tides during most of the winter frequently prevented examination of the lower and/or more exposed areas.

The encroachment of the mussels on the areas was still progressing, e.g., Area 2 (Plate 2). The fauna and flora inhabiting Area 2 was almost the same both in numbers and species as that noted on 28th March.

Area 4 was dominated by *Galeolaria* as the *Ulva* and surrounding mussels had been removed from the rock by some unknown agencies. There were also 19 *Mytilus planulatus* and a few *Chthamalus antennatus* on this area.

Patelloida marmorata, P. diemenensis, Fossarina petterdi, Siphonaria zonata, S. diemenensis and *Cominella lineolata* were all found roving on Areas 2 and 4.

12*th May*, 1951

A south-westerly swell made it impossible to examine Areas 1, 3 and 5.

In spite of bad weather the mussel beds were still intact and continuing to encroach on to the cleared areas. All of the young barnacles on Area 4 had died. These animals were noted as settling in February. The roving species were not common as they had probably retired to less exposed places to avoid the storm. *Sypharochiton pellis-serpentis, Patelloida alticostata, Siphonaria diemensis* and one *Cellana limbata* were recorded.

Area 6 was unchanged with *Mytilus planulatus* still the dominant organism.

23*rd June*, 1951

There had been little change in the population of any of the areas with the exception of Area 5 where a *Polysiphonia* sp. had become very plentiful. This area was surrounded by mussels covered by *Ulva* but the green weed was not growing on the bare rock.

Eight barnacles were found on Area 1. Six of the barnacles were large and must have settled since the area was last examined in March. The other two were small and represented a recent spatfall. In spite of a large and successful spatfall the barnacles failed to colonize the available space.

The encroachment of the mussels on to the areas was slowly continuing. One large adult mussel was found near the centre of Area 1. The mussel measured 2½ inches in length and was too large to have grown from a larva. Area 5 was difficult to examine in detail due to a more or less permanent flow of water over the shelf on which the area was situated. It was possible to determine that a *Polysiphonia* sp. was the dominant form on the area, but the surrounding mussel beds were covered with *Ulva*. Area 6 showed no change.

Area 3 was slowly becoming colonized by a purple-pink coloured *Lithothamnion* sp. This alga was spreading from the top of the area down towards the bottom. One specimen of *Balanus trigonus* had settled in the bottom seaward corner of the area. A few small patches of the black lichen, *Verrucaria* were also noted as well as two small *Catophragmus polymerus*.

15*th August*, 1951

It was not possible to examine Areas 1, 3, 4 and 5 due to the state of the weather. Area 6 was unchanged from the June visit. Area 2 was covered by *Ulva* and it could be seen that Areas 1 and 5 were similarly populated.

23*rd October*, 1951

No large spatfalls had occurred on any of the areas since August.

The original foot square cleared to form Area 1 was greatly reduced by the encroachment of the mussels from the surrounding beds. Four large mussels had also moved into the centre of the area (Plate 3). Only five barnacles were found, four of these being *Elminius modestus* and the other one was a *Chthamalus antennatus*. Some *Ulva* plants were living on the seaward corner of the area.

Area 2 was also being slowly covered by the mussels. Some roving species (*Patelloida alticostata, P. pauperata* and *Siphonaria diemenensis*) were found as well as six *Elminius modestus*. A few *Ulva* plants were also growing on the area (Plate 4).

Area 3 was dominated by *Verrucaria*. The neighbouring mussels did not invade this area. One large *Catophragmus polymerus* was found on the area as were also *Siphonaria zonata, S. diemenensis* and *Patelloida alticostata*. The *Corallina* plants noted earlier had vanished from the area and the *Lithothamnion* invasion was proceeding slowly.

Area 4 was being populated by *Galeolaria*. A few *Patelloida alticostata, Siphonaria diemenensis* and *Mytilus planulatus* were also on the area.

The mussels surrounding Area 5 were encroaching on the cleared patch, which was completely covered by *Ulva*. Six *Elminius modestus* and several *Patelloida alticostata* and *Siphonaria diemenensis* were also living on Area 5.

Area 6 showed no change.

30*th October*, 1951

During the latter days of this month a very heavy southerly gale blew into the estuary of the River Derwent. A visit was made on this date to ascertain the damage inflicted by the storm on the mussel beds. A heavy swell was still running and it was not possible to get within 100 feet of the mussel beds.

7*th November*, 1951

As a result of the storm noted above the mussel beds and cleared areas ceased to exist (Plate 4). The regeneration of the mussel beds will take several years and must take place from a residual stock which survived in sheltered situations on the platform as shown in Plate 5.

Discussion

The experiment, although incomplete at the time of the storm had progressed sufficiently far to enable certain conclusions to be drawn. In the case of Areas 1, 2 and 5 there was considerable encroachment by the surrounding mussels on to the cleared areas. If permitted to continue this encroachment would have been complete and recolonization of the rock would have been achieved in a comparatively short time (two or three years).

Area 3, which was situated in a vertical cleft, was not being recolonized by mussels although there were thick beds beside the area. On these vertical beds there must be little or no force pushing mussels outwards into the cleared area. The encroachment by the mussel beds on the areas noted above was caused by such a force acting parallel to the rock surface. This force is probably gravitational, resulting from the very dense mussel population on the beds. On the vertical face this force would be downwards in direction and would tend to promote a mechanical instability in the mussel beds.

The mussels surrounding Area 4 were denuded early in the experiment. *Galeolaria* became the dominant organism. The recolonization by the serpulid was rapid but incomplete. It is probable that in time the mussels will re-occupy the area temporarily taken over by the serpulids, though the recent gale will greatly extend the time required for this process.

Area 6 showed very little sign of recolonization. The area is higher on the shore than the other places and this probably affected the rate of settlement of larvae as well as diminishing their chances of survival after settlement. The mussels surrounding the area were not as closely packed as at other areas and were also of a different species, namely, *Brachyodontes rostratus.*

Both experiments show that there is a very slow rate of colonization of rock surfaces. Winter Rock B, after 5½ years in the sea was only partly colonized. Similarly those cleared areas where there was no pressure from surrounding mussel beds showed very little recolonization. From both experiments it seems as if barnacle spatfalls take place throughout the year. In the colonization experiment a large spatfall took place in July, while in the recolonization experiment, a heavy spatfall occurred in March. Dakin and Colefax (1940) found barnacle larvae at all times of the year off the New South Wales coast. In both experiments the initial settlement seemed to be quite successful but soon afterwards some factor or factors caused very severe casualties to, if not total annihilation of, the young barnacles. This high death rate was probably due to a combination of tidal and climatic factors as noted in Guiler (1950).

The presence of many grazing forms, e.g., the chitons and patelloids, points to the presence of a good supply of minute algae. Wood (1950) notes that a bacterial film does not form on submerged test plates but he notes that the small algae are plentiful on the same type of substratum.

The growth rates of the mussel, *Mytilus planulatus*, appears to be very rapid in the early stages. The mussels on Area 1 grew to a length of 2½ inches in a period of about nine months and certainly they were above the minimum size for reproduction. It seems probable that the barnacles also grow to a reproductive size in one season.

The main conclusions to be drawn from the above experiments are that colonization or recolonization is very slow. In the mussel beds, recolonization is achieved by encroachment of the mussels except on vertical faces where a slower settlement process operates. The encroach-

ment is by population pressure round the edges of the square as well as by a few large mussels wandering across the cleared area (Plate 4). There was very little successful mussel settlement.

The mussel beds are subject to catastrophic changes which greatly affect, if not stop, all recolonization by encroachment. Almost two years after the gale which denuded the rocks there is an almost continuous bed of mussels over nearly all the area previously colonized. However, the mussels are all small in size. This rapid recolonization could not have been achieved by encroachment and must have come about by successful larval settlement. From the size of the mussels it would appear that two periods of successful settlement took place. Thus the recolonization after a natural denudation is more rapid than that taking place after artificial clearing of a surface.

Long term changes also alter the status of mussel beds and such a change has been noted at Coles Bay where the mussels replaced *Hormosira* on the shore (Guiler, 1953).

(c) Seasonal growths

It was noted in Guiler (1950) that a diatom growth appeared on the shores in 1948, but this growth did not appear in 1949 or 1950. The winter of 1951 showed some diatom growth on the shore but the density of the colonies was not nearly as great as in 1948. The winters of 1949-51 were notable for the lack of rain and it is possible that this factor prevented the establishment of a strong diatom growth. In 1952 and 1953 the diatom growth was very marked.

(2) Algae

Apart from secondary colonization of the diatom region by several species, as noted above, there are only three algae which are found forming a seasonal growth on the shore. They are *Porphyra columbina* Mart., *Scytosiphon lomentarius* (Lyngb.) J. Ag. and *Ulva lactuca*, L. These first two species were very common on the shore in the winter of 1951, being recorded from Howrah, Kingston, Blackman's Bay, Eaglehawk Neck and Dover. The algae formed two permanent bands in the Midlittoral. *Porphyra* was found as high as the barnacles but in some places the weed was found as high on the shore as the littorinids. Below the *Porphyra* belt was the *Scytosiphon* belt. This belt extended as far down the shore as the mussel beds. These mussel beds may be covered by a dense growth of *Ulva* so that the shore in winter presents the unusual feature of an algal zonation . . *Melaraphe, Porphyra, Scytosiphon, Ulva, Cystophora.*

The algal growth usually appears in late August (Plate 6) and persists until early November. By that time, the algae were becoming very dry and only just managing to survive. The growth disappeared shortly later, when the heat of the early summer sun was experienced.

There are three varieties of *Scytosiphon*. These varieties occur at different tidal levels. The variety to be seen at the highest level on the shore is a stunted form with very poorly developed internodes. This variety, when dry, looks like withered or dead *Zostera*.

The varieties found about the level of the barnacles show development of the internodes while the variety found above the mussels has very well developed internodes and is more fleshy in appearance than either of the other two varieties.

Ulva lactuca can be found at all times of the year on the mussel beds but in the spring and early summer the species forms a complete cover for the mussels. The dense growth of *Ulva* does not survive for long into the summer, only scattered plants being found on the mussels. The ponds of the Infralittoral fringe usually have *Ulva* growing in them all summer. Womersley (1950), Dellow (1950) note the seasonal growth of *Porphyra* in South Australia and New Zealand and Newton (1931) and Chapman (1950) both note the seasonal occurrence of the genus in Europe.

Often associated with the appearance of these three algae is the upward extension of the range of certain of the roving gastropods, such as *Cominella lineolata* and *Austrocochlea obtusa*. I have not noticed any appreciable change in the distance the limpets are found above the mussels. *Gelidium* and some other red algae extend further up the shore but on the disappearance of the original algae all these species soon disappear. Young mussels, *Mytilus planulatus*, have been noted to settle very far up the shore during the period of algal growth. It is possible that the mussels found high on the shore in such places as Kettering are enabled to settle during a period of algal colonization. Bishop (1947) notes that mussels settle on a colonized surface and the presence of an algal growth on the rocks fulfils this condition.

(3) Animals

The only seasonal animal migrations are those which occur in the early or late summer or as a result of the unusual algal or diatom growths. In the early summer numerous roving forms are found in the Infralittoral fringe and the ponds of the Infralittoral fringe. There are small fish, *Scutus antipodes*, *Nudibranchs*, tectibranchs, the urchin *Helocidaris erithrogrammus* and a Crinoid which breeds under stones. These species all return to deeper water in the autumn.

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Plate 1.—Winter Rock B, November, 1951. The chitons are *Amaurochiton glaucus*, and the serpulids are *Galeolaria* with some *Serpula*. Note the almost complete absence of barnacles.

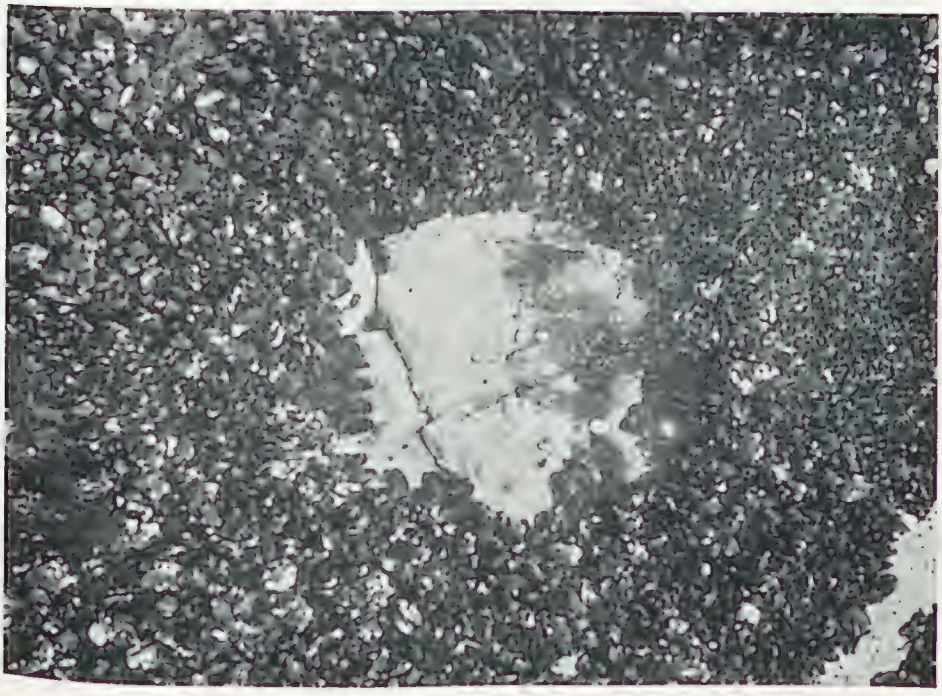

Plate 2.—Area 2, 10th April, 1951. Note the encroachment by mussels on to the cleared area. The seaweed growing on the area is *Ulva*.

Plate 3.—Area 1, October, 1951. The encroachment by mussels is most obvious and large mussels which have migrated into the centre of the area can be seen. The alga is *Ulva*.

Plate 4.—Area 2, October, 1951. Note the barnacles and molluscs which have invaded the area.

Plate 5.—The mussel beds after the gale which destroyed most of the mussels. Area 1 was situated on the small shelf in the middle of the photograph.

Plate 6.—A dense seasonal growth of *Scytosiphon lomentarius* at Blackman's Bay, September, 1951.

Notes on Some Tasmanian and Australian Lepidoptera-Rhopalocera

with Descriptions of New Forms and Subspecies

L. E. Couchman, F.R.E.S.

with 1 plate and 2 text figures

Summary

The origin and possible localities for typical *Heteronympha cordace* Geyer are discussed, and the southern ranges of New South Wales designated as the habitat of the nominotypical subspecies. The range and variation in Australia is studied, and the three Tasmanian geographical races, ssp. *comptena*, *kurena* and *legana* are described and their range and relationships defined. A westward extension of the range of *Orcixenica pt. ptunarra* Couchman is recorded and the subspecies figured.

An additional species is added to the list of Tasmanian butterflies, *Neolucia serpentata* ssp. *lavara* from the Cambridge shore-line.

Donovan's original figure of *Delias harpalyce* is discussed and shown to be of the autumn brood, the distinctive spring brood is named f. *adina*. A new female form of *Delias aganippe* Donovan, f. *koornalla*, is described from Victoria.

Anisynta albovenata ssp. *weemala* and *A. cynone* ssp. *gunneda* are described from Gunnedah, N.S. Wales; the former hitherto only known from Yorke's Peninsula, South Australia, the latter from several localities in South Australia and Victoria.

These notes form a further contribution to our knowledge of the Tasmanian and Australian butterfly fauna. In all cases except where otherwise stated the types are in my own collection.

SATYRIDAE

Heteronympha cordace (Geyer) (1832)

(figures 1-4 and 2 maps)

This species has been recognised as Australian since Butler (1868) in the errata to his " Catal. Diurnal Lepid. Satyridae . . British Mus." gave " Melbourne " as the locality for specimens in the museum collection. On p. 166 of this catalogue Butler had followed Westwood [1851] in placing it as from " East India ", the latter author evidently quoting Geyer, who in describing the butterfly in 1832 states " Hierath Ostindien ". Melbourne at sea level even a century ago would be a most unlikely haunt, since except in the extreme south and west of Tasmania *cordace* seems always confined to upland swampy areas where its foodplant, *Carex*, is common. Within recent years the nearest localities known are Emerald, c. 700 feet, 32 miles east in the hills beyond Belgrave; and Narbethong, c. 1200 feet, 53 miles N.E. in the Victorian Alps. Lilydale, whence F. Spry (1893) obtained specimens is now a farming area and the species only a memory. I have no record from any locality nearer Melbourne,

nor of any *cordace* taken at sea level on the mainland. It seems likely that with this species, as with others, Butler's reference is to the point of despatch, not the place of capture, and Melbourne must be rejected as the possible type locality for this, as for other reasons to be discussed later.

Authors have noticed differences in specimens from several localities, for example, Waterhouse and Lyell (1914) where they say that Ebor specimens "are much darker than the average", and Burns [1948] who in separating ssp. *wilsoni* from south-western Victoria, noted the smaller examples found on Cradle Mt., Tasmania, and again drew attention to the darker specimens from the northern limits of the species' range. No Australian author has attempted to settle the question of a type locality, or, perhaps because of the difficulty in consulting the original figures, of deciding whence Geyer may have had his specimens. The discovery of other new forms now makes it imperative that this question should be settled.

Hubner's "Zutrage z. Samml. exot. Schmetterlinge" was continued after his death in September, 1826, by Geyer. The plates contain illustrations usually showing the upper and underside of each species, but there are no names on the plates, "all the names appearing for the first time in the text" (Hemming 1937, p. XXII). In vol. 4, figs. 797, 798, show our insect, which on page 42 is named *Tisiphone cordace*. Since no copy of this rare and costly work could be found in Australia, I am indebted to my friend, E. E. Syms, who consulted copies in London, and through him to the Trustees of the British Museum (Nat. Hist.) and Mr. W. H. T. Tams for the photograph of Geyer's figures which I am able to reproduce.

Hemming (1937, I: pp. 460, 479) gives the date of publication of figs. 765 to 800 (plates [132]-[137]) as 2 July 1827, to 31 December, 1831; the text p. 42 as 1832, the date of publication of the species name, so that the plate antedates the text by several years at least. The possible locality for the original specimens must obviously be governed by the early dates for the figures, and in this connection it must be remembered that the insect can only be collected in its special haunts from late December to early March, and that even a direct voyage to Europe during the early 19th century occupied half a year. This, together with the time necessary for the production of the plate would mean that the insects could not well have been taken later than 1825, almost certainly much earlier. At this date the colonies of New South Wales and Van Diemen's Land, as then known, are the only localities needing consideration.

Geyer's f. 797 has the costa of forewing evenly rounded, the submarginal spots of hindwing in Ib, 2, 3 and 4 are clear and in 3 and 4 are large and distinct, indicating the figure is that of a female. The subapical ocelli of hindwing are large and clearly surrounded by a dark ring; this at once removes Tasmania as a possible locality, since the mountain forms found here have only a minute ocellus, rarely with a fine ring, while the form from sea level at Macquarie Harbour and Port Esperance in addition to other distinctions is also without the ringed ocelli.

Victoria had not then been separated from the mother colony, but unless the specimens were taken during or very soon after Hume and Hovell's journey in October, 1824, they could not well have come from any of the known localities in that State. In New South Wales the species is only found at an altitude above 3000 feet in the Dividing Range, so that it is unlikely the butterfly was found before the first crossing of the Blue Mountains in 1813. It is still found in areas around Medlow Bath and Blackheath, but neither this form, nor the darker one from the Barrington Tops and the Dorrigo plateau further north resembles Geyer's figure. However, in a long series of both sexes from Mt. Kosciusko (4000 feet) in the A. N. Burns collection, I noted females which on the upperside closely agree with the original figure (f. 797), on the underside the only difference is in the comparative lightness of the discal band across the hindwing, in the original figure, f. 798, this is rather darker than in any specimen I have seen.

I think it reasonable to assume that the originals of Geyer's figures were most probably collected between 1813-1825, when the early explorers were pushing out in a south-westerly direction from the first settlements, and that they came from the mountain ranges of southern New South Wales, within the area encompassed by the Snowy Mts., the Munyang and the Monaro Ranges, and I would designate this as the type locality. Further collecting at an altitude in this district may make it possible to restrict the type locality still further.

The Australian Subspecies

Heteronympha cordace cordace (Geyer) (1832)

This name has usually been attributed to Hubner, e.g., Waterhouse and Lyell (1914), Waterhouse (1932), but Hemming has shown that Geyer must be regarded as the author. According to Horn and Kahle (1935) Hubner's types of lepidoptera went via Mazzola to the Naturhist. Museum, Vienna, but Dr. M. Beier, who kindly searched through the Museum collections, (in litt) tells me that *cordace* is not to be found, and that if in fact the type ever was in the Hubner collection it now seems hopelessly lost. This subspecies, as I have restricted it, with the ground colour Cadmium Yellow (Ridgway 3) and the markings as in Geyer's figure, is found throughout the ranges of southern New South Wales, it has been taken at Mt. Kosciusko, Moonbar, Kiandra and Nimmitabel at all altitudes from 3500 to 5000 feet by a number of collectors, and those I have seen from further north in the Aust. Capital Territory (Lees Springs, 4000 ft. D. Waterhouse) do not differ markedly, to the south at altitudes in the Australian Alps (Cobungra, 5000 ft. A. N. Burns), (Glen Wills, 3250 ft. F. E. Wilson) the same general form persists.

Specimens from the lower levels in Victoria, Milgrove, Warburton, Narbethong, Emerald and other localities in the hills, as well as those from Macedon and the Mt. Buangor Range further west do not differ sufficiently to warrant separation from the nominotypical race.

MAP 1.—Map of south-eastern Australia showing the range of *H. cordace* X *H. c. cordace.*

To the north in the Blue Mts. the butterfly is found at altitudes over 2000 feet (Hampden, R. J. Tillyard; Woodford, 2000 ft., Medlow Bath, 3400 ft., and Blackheath, 3500 ft., G. A. Waterhouse), 150 miles north-east it has been taken in several localities on Barrington Tops from 4000-4900 feet; and again further north near Dorrigo (Ebor, 4700 ft. R. J. Tillyard; Deervale, 4500 ft., A. N. Burns).

Specimens from this northern part of its range show a gradual tendency to darken, those from the Dorrigo district diverging most clearly from the typical form. The submarginal spots of fore and hindwing tend to disappear in males from Barrington Tops, while in 15 males from Ebor seven have these spots obliterated by the black band. In the females these markings although small are still present, but the general ground colour is restricted by the greater width of the black bands when compared with specimens from southern New South Wales. Although seemingly distinct enough when considered alone, the Deervale-Dorrigo-Ebor specimens actually grade into those from Barrington Tops, while these latter form a transition to the nominotypical race from the alpine areas of the New South Wales-Victorian border. From south to north *c. cordace* clearly shows a pigmentation cline for the melanic markings of the fore and hindwing above, yet specimens from the middle of its range, i.e., northern Victoria and southern New South Wales, can be

matched by examples from either extreme. Geographically there is no barrier between Dorrigo and the Barrington Tops, and the butterfly should be found at other spots in the ranges between. The Hunter River valley and the Cassilis Gap certainly isolate the northern insect from the Blue Mts., but in the long series I have studied I can find no constant character for separation, in fact this is true of the butterfly throughout the whole of its 900 mile range, from near Ararat in Victoria to Dorrigo in N.S.W. The transition is gradual and unbroken, so that I do not make further divisions. There is some doubt as to whether specimens from the Grampians should be included with *c. wilsoni*, I have seen very few examples, but with the recent discovery of *c. cordace* in the Mt. Buangor ranges I incline to place them with the latter subspecies.

It is remarkable that the darker specimens should appear in the northern part of its range, reversing the variation found in other satyrid butterflies restricted to the higher altitudes, e.g., *Oreixenica lathoniella* (Westwood). Since experience in Europe has shown that increased temperatures shorten the pupal stadium and depress the formation of melanin it might have been expected that the northern specimens would have tended to become lighter, whereas the reverse is true. Apparently the greater altitude at which the species is found in northern N.S.W. must be sufficient to counteract the climatic influences.

Variation seems to consist chiefly in the presence of additional ocelli on the upperside hindwing, most often in area 5 below the subapical ocellus. A remarkable aberration in the F. E. Wilson coll. has the normal ground colour replaced by white. A male, the forewing length, 23 m.m., the markings, and the ocelli are quite normal; it is labelled Emerald, Vict. 7-2-43. F. E. Wilson.

H. c. wilsoni Burns [1948]

This, the south-west Victorian subspecies, can be easily separated by the characters of the hindwing beneath, the ground colour is lighter and clearer, the discal band less distinct, the subtornal ocellus in both sexes much reduced in size, often absent in the male, the subapical ocellus in the female minute and in the male absent. Typically from Dartmoor on the lower Glenelg River, it is found in a restricted area and is not common where it occurs, it is distinct in appearance and seems isolated geographically; specimens from the Grampians and the Mt. Buangor ranges further east I consider better placed under ssp. *cordace*.

The Tasmanian Subspecies

In Tasmania the species is found in three areas, not greatly separated by distance, but existing where climatic influences are much more varied than elsewhere in its range in Australia. This is another instance of the development of racial differences in a species inhabiting a small island where favourable conditions are present for such development.

H. cordace comptena n. subsp.*
(FIGURES 3 AND 4)

Above, ground colour Cadmium Orange (Ridgway 3), brighter in tone than in nominotypical *c. cordace* from the Mt. Kosciusko district.

Male, above, the discal spot in area 4 of hindwing is large and completes the row of spots between subapical and subtornal ocelli, subapical ocellus without the surrounding dark ring, submarginal spots in areas 3 and 4 larger and more clearly defined, subapical ocelli of fore and hindwing with large blue pupils, subtornal ocellus of hindwing with blue pupil 1·5 m.m. diameter.

Female, above, as in male, a clear white dot in area 5 below subapical ocelli of fore and hindwing, subtornal ocellus of hindwing elongated, with a large elongated blue pupil 2 m.m. wide.

Male and female beneath with large clearly defined post-discal white spots in areas 3 and 4 of hindwing, in the female 3 m.m. diameter; female with an additional white spot surrounded by a dark ring in area 5 below subapical ocellus.

MAP 2.—Map of Tasmania showing the range of *H. cordace* ssp.
○ *H. c. comptena;* ⊙ *H. c. kurena;* ▣ *H. c. legana.*

Male, forewing length 22 m.m., female 22 m.m.

Holotype male labelled Strahan, Tas. sea-level. 23-January-1950 L. E. Couchman.

Allotype female, data as for male.

The most richly coloured of all the *cordace* races, ssp. *comptena* is readily distinguished above by the large blue pupils of the ocelli, and the large and clearly defined white spots of areas 3 and 4 of hindwing beneath, which with the additional ocellus in 5 form a complete curved series from apex to tornus. The additional white discal dots in area 5 of both fore and hindwing above in the female make this sex very distinctive. I have seen a few specimens from Zeehan which do not differ materially, and consider those from Dover collected by S. Angel should also be included here. This is a coastal race found at or very near sea level in areas of 40-70 inch rainfall. The type series was collected within a few yards of the sea near Strahan and it seems likely that it will be found in similar localities around the western and southern coastline as far as the Port Esperance area.

* Comptena, spirit of the dead of the western tribes.

H. cordace kurena n. subsp.*

Male, female, ground colour above Orange (R.3), markings as in ssp. *cordace,* with an additional small post-discal orange spot in area Ib of forewing, larger in female.

Male above, submarginal spots in 3 and 4 of hindwing small and round, subapical ocelli of fore and hindwing small, round, 1·5 m.m. diameter, with minute white pupil, that of the hindwing without a surrounding dark ring; subtornal ocellus of hindwing small, round, 3 m.m. diameter, with small white pupil.

Female above, the submarginal spots of both wings as in the nominotypical female, but differing in the much larger discal spot of area 4 of hindwing, the ground colour seeming to form a band only slightly constricted in area 4, a minute white dot in area 5 of hindwing below subapical ocellus. Female beneath, the hindwing with clear white post-discal spots in 3 and 4, a small ocellus surrounded by a dark ring in 5, forming with the subapical and subtornal ocelli a curved series across the wing.

Male forewing length 18·5 m.m., female 20 m.m.

Holotype male; Cuvier River, Tas. 2500 ft. 5 Jan. 1948 L. E. Couchman.

Allotype female, similarly labelled.

This is quite the smallest race, males and females average only two-thirds the expanse of ssp. *cordace.* Distinguished above by the extra post-discal spot in Ib of forewing, and the small subapical ocellus of hindwing not surrounded by a dark ring.

In our experience ssp. *kurena* is confined to " button grass " swamps in areas with rainfall from 70 to 110 inches on the western plateau from Derwent Bridge to Cradle Mt., at an altitude of 2400-2900 feet. Typically from the valley of the Cuvier River between Lake Petrarch

and Lake St. Clair, its weak flight probably prevents it crossing the western mountains to meet ssp. *comptena,* while the drier valleys of the Macquarie and South Esk impose an effective barrier to the east in the direction of the next subspecies. A series of four males and two females from Hampshire on the Emu River, altitude 1520 feet, differs only in its slightly larger size; while a number of males collected in the valley of the Dee River 22nd January, 1946, close to the Lyell Highway, altitude 2200 feet, are also hardly to be distinguished. This, the most easterly locality for this mountain race, as it also was for the mountain subspecies of *H. penelope* Waterhouse (*H. p. panope* Waterhouse), is now cleared and will soon be inundated by Hydro-Electric Commission developments.

* Kurena, little, in the dialect of the eastern tribes of Tasmania

H. cordace legana n. subsp.*

Male, female, intermediate in size between ssp. *cordace* and ssp. *kurena,* ground colour as in *c. cordace,* black markings narrower than in *c. kurena.* Male above, submarginal spots of fore and hindwing larger than in ssp. *cordace,* those in 3 and 4 of hindwing large and triangular in shape, subapical ocelli of forewing and subtornal of hindwing as small as ssp. *kurena,* but the subapical ocellus of hindwing is reduced to a minute black dot. Female above, submarginal spots in 3 and 4 of forewing are both large and square, the hindwing has a complete submarginal band of spots from 1 to 6, those in 3 and 4 large and semilunular; discal band much broader in area 6 with the subapical ocellus in its centre, the spot in 4 although narrowed is still much larger than in ssp. *cordace.* Hindwing beneath in both sexes lighter and with an illdefined darker discal shading, subtornal ocellus small, subapical ocellus minute, with very small but clearly defined white post-discal spots in areas 3 and 4.

Male forewing length 20·5 m.m., female 21 m.m.

Holotype male; Lake Leake, Tas. 2100 feet. 21 Jan., 1951, L. E. Couchman.

Allotype female; same locality and collector, dated 20 Jan. 1951.

Ssp. *legana* is clearly distinguishable in both sexes by the reduction of the subapical ocellus of hindwing above, in many males it becomes a small black dot. Beneath it approaches ssp. *wilsoni* in the reduction of the hindwing ocelli, but above the lighter ground colour and the extended submarginal series of spots readily distinguish it from this south-west Victorian as well as the other known subspecies. Typically from swamps in the immediate vicinity of Lake Leake at altitudes between 1900 and 2100 feet, ssp. *legana* will include specimens from Mt. Barrow at altitudes of 1750-2400 feet, collected by N. B. Tindale, 9 February, 1949. It is noteworthy that this north-eastern Tasmanian subspecies is most nearly related to ssp. *wilsoni* from south-western Victoria, not, as might be expected with the race from the Victorian ranges, which geographically speaking is comparatively close. The western Tasmanian ssp. *comptena* on the other hand has some affinities with the New South Wales race, but is still the most divergent of all *cordace* subspecies.

* Legana, the eastern tribes' word for fresh water

Oreixenica ptunarra ptunarra Couchman 1953

(FIGURES 5, 6)

When describing this remarkable new species I had specimens of the nominotypical subspecies only from Miena, altitude 3300 feet, at the southern end of the Great Lake. It has since been found to occur west and south of the original locality, specimens were taken on March 8th, 1953, at 3600 feet on the road from Liawenee to Lake Augusta; earlier, March 2nd, a pair had been taken about a mile west of the Marlborough Highway where it crosses the Ouse River at an altitude little if any higher than the Great Lake. The western limits of ssp. *ptunarra* are still not known, though collecting in the vicinity of Lake St. Clair has so far proved fruitless there seems no reason why it should not extend at least to the eastern shores of this lake.

LYCAENIDAE

Neolucia serpentata lavara n. subsp.*

Male above, basal blue areas of fore and hindwing extending further towards outer margins than in ssp. *serpentata* Herr.-Sch., the blue being close to Amparo Blue (R.9), without the purplish tinge of mainland specimens. Beneath, white markings of fore and hindwing are more prominent because of the darker ground colour, discal blotches of hindwing from costa to vein 4 black, much more prominent than in the nominotypical subspecies.

Holotype male; Cambridge, Tas. sea level, 5 April, 1952, L. E. Couchman.

Allotype female; same locality and date, collected by J. R. Cunningham; in the collection of the Tasmanian Museum.

This is a new record for Tasmania, the species first being noted by J. R. Cunningham, 30 March, 1952, on the mud-flats near Cambridge, subsequently we found it to be not uncommon, attracted to the flowers of the introduced African box-thorn (*Lycium* sp.).

I possess one specimen, from a series of three taken at Whitemark, Flinders Island, 30 January, 1949, by N. B. Tindale, but this is typical ssp. *serpentata,* differing in no way from Victorian and South Australian examples. A smaller and darker race, ssp. *lavara* can be easily distinguished by the different shade of blue above, and beneath by the prominent white and black markings, particularly of the hindwing.

* Lavara, an aboriginal word for little

PIERIDAE

Delias harpalyce (Donovan) (1805)

Donovan describes this from " New Holland " with no indication as to the source of the specimen or its exact locality. Considering the known range of the butterfly and the date shown on plate 18, Jan. 1, 1805, it is certain that the original example could only have come from near Sydney, and this must be accepted as the type locality.

Westwood (1872) discusses Donovan's method of preparing his plates, and Waterhouse (1938) deals with a number of Donovan's figures that were copied from W. Jones' unpublished Icones, but *harpalyce* is not noted among these. The underside figure of *harpalyce* is however so crude that I have no doubt it was drawn in the same manner as other species noted by Westwood and Waterhouse, i.e., the upperside taken direct from a specimen, or copied from Jones' figures, the underside painted from notes made of the differences between upper and underside. Only in this way could an artist of Donovan's ability make such an error in the shape and position of the scarlet post-discal band. The angle formed by the band is not sufficiently acute, the costal spot too large and too far from base and the spot in area 5 too square and not produced towards outer margin. The upper side figure is however a good representation of the male of the late summer brood, in which the forewings have a submarginal band of small grey-white spots in areas 4 to 8.

The spring brood is distinctive and my friend C. G. L. Gooding, of Moe, Victoria, who has collected and bred this butterfly extensively for many years has called my attention to the constant differences.

D. harpalyce f. adina f. nov.

This is the spring generation, distinguished in the male upperside forewing by the size and extent of the submarginal band of spots, these are much larger than in the late summer form, in some specimens they extend almost completely across the black border, and there is an additional slightly smaller spot in area 3.

The female also has these submarginal spots much larger than in the late summer form, in addition there is some scattered grey-white scaling in areas 1 and 2, completing the band from costa to tornus; basal area of forewing and hindwing clearly greenish-grey, extending further towards the hind margin than in f. *harpalyce*.

Holotype male; Moe, Vict. 20 October, 1952, C. G. L. Gooding. Bred ex pupa.

Allotype female, similarly labelled.

Paratypes in the Gooding and my own collections.

The differences have been noticed by authors, e.g., Talbot (1937, Monograph Pierine Genus *Delias* (6) : 427) but none seem to have realised that they were seasonal in character. Variation in this species occurs chiefly on the underside, consisting either of an extension of the basal black areas of fore and hindwing over the normal grey-white discal areas, in two female examples in the Gooding coll. from Moe, dated 14-11-1925, the black area of the hindwing extends from base to the scarlet post-discal band, while several other specimens grade into this extreme form; or the scarlet post-discal band of the hindwing itself is restricted, a bred female in the same coll., dated 20-10-1938, from Moe has only a few red scales in areas 2, 3 and 4, with traces of spots in 6 and 7, the costal spot alone being distinct.

The same collection includes two remarkable gynandromorphs; the first, bred from Moe, dated 23-10-52, has the normal female genitalia, the shape, colour and markings of the right fore and hindwings are as in a normal female, with the subterminal band of forewing continued into Ib and Ia, but the left fore and hindwings are those of a male, also with faint subterminal spots in areas Ib and Ia. The second specimen, similarly labelled, is also a female with the wing shape and genitalia of a female, but the colour and markings are those of a male, the only noticeable difference is in the slightly narrower black margin of the hindwing above.

Delias aganippe (Donovan) (1805)

A batch of thirty full-grown larvae taken by Miss Margaret Gooding feeding on *Loranthus* growing on *Acacia dealbata* on the banks of Traralgon Creek, Victoria, January 20th, 1951, produced among others eight females in which the normal grey-white ground colour is replaced by Martius Yellow (R.4), the markings above and beneath as in typical *aganippe*.

I call this f. *koornalla* f. nov.* Holotype female labelled Traralgon Creek, Victoria, February 9, 1951, Margaret Gooding; in the Gooding coll., with paratypes similarly labelled in the same collection and in my own.

* Koornalla, an aboriginal name for the district

HESPERIIDAE

Anisynta a. albovenata Waterhouse 1940

The holotype male in the Australian Museum has the spot at end of cell 1 m.m. square, with traces only of two subapical spots, two minute post-discal dots in 4 and 5 and another minute discal dot in area 2.

Forewing length 12·5 m.m.

The female allotype in the same collection has the cell spot of the same size and shape as the male, but with three distinct subapical spots, two post-discal spots in 4 and 5 and three discal spots in Ib, 2 and 3.

Forewing length 15·5 m.m.

A. a. weemala n. subsp.*

Male above, spot at end of cell as in ssp. *albovenata*, 1·5 m.m. square, but with three distinct subapical spots, two post-discal spots in 4 and 5 as large as cell spot, one discal spot slightly smaller in lower half of Ib, and a small streak above it in upper half of Ib.

Beneath, differs from the nominotypical subspecies in that the spots of forewing are as large as above, yellow; hindwing ground colour brown, with an angular grey discal band broken by the white veins extending from vein 8 at half to vein Ib, broadest in areas 3 and 4.

Female above, markings as in male, yellow; spot at end of cell 2 m.m. square, spot and streak in Ib larger than in male. Beneath, forewing as in male, hindwing the discal band continued by basal spots in upper and lower half of area Ib, and basal spots above and below vein 7.

Male forewing length 13 m.m., female 14·5 m.m.

Holotype male labelled Gunnedah, N.S.W., 10 September, 1943, F. S. Paul.

Allotype female labelled as male.

Paratypes similarly labelled in the F. S. Paul and my own collections.

Ssp. *weemala* is easily distinguished above by the larger markings, beneath by the brown ground colour and clear discal band of hindwing. It keeps to the hills at c. 1000 feet altitude, the flight is short but very fast and it is fond of settling on bare patches of earth with wings outspread; taken from 10 September to 2 October, 1944.

Specimens are in most Australian collections and Evans (1949, Catal. Hesperiidae Europe, Asia and Aust.; 211) refers to one male in the British Museum. Waterhouse had separated Gunnedah specimens in his coll. as a new subspecies, but had not named them.

This is a remarkable extension in the range of the species, first described from Yorke's Peninsula, South Australia, now recorded from Gunnedah, N.S.W., 850 miles north-eastward, and my friend F. S. Paul is to be congratulated on his discovery of this and other S. Australian species in this unexpected locality.

* Weemala, Kamilaroi for distant view.

A. cynone gunneda n. subsp.*

Male and female above distinguished from ssp. *grisea* Waterhouse 1932 by the reduction of markings of forewing to minute dots; beneath the forewing of male with three subapical dots only; hindwing of male and female overlaid with yellow scaling, post-discal spots indistinct without the black anterior edges found in ssp. *gracilis* Tepper 1882.

Male forewing length 11·5 m.m., female 12·5 m.m.

Holotype male labelled Gunnedah, N.S.W., 26 March, 1944, F. S. Paul.

Allotype female, as male.

Paratypes in the F. S. Paul and my own collections.

Nominotypical *cynone* Hewitson 1874 was restricted to the area around the mouth of the Murray River by Waterhouse; ssp. *gracilis* Tepper 1882 is found in several localities near Adelaide, South Australia; ssp. *grisea* Waterhouse 1932 is from Kerang on the Loddon River in northern Victoria, while ssp. *gunneda* extends this range to Gunnedah in northern New South Wales. This town is 876 feet above sea level, and *c. gunneda* ranges from this altitude to c. 1100 feet. An autumn butterfiy, it has been taken from 11 March, 1944 to May 17, on the latter date it was getting scarce. Nothing has been written of the early stages, so the following note kindly communicated by my friend F. S. Paul, although incomplete, is worth recording.

The egg is cream in colour with about twelve vertical ridges, showing white against the ground colour, converging to a slightly darker micropylar area; slightly wider than high, flattened at the base and laid singly on stems of "snow grass" (*Poa* sp.?), though on one occasion, 8-4-1944, three eggs were observed on one stem about 1/16 in. apart.

Waterhouse had also separated ssp. *gunneda* as a distinct race in his collection but had not named it. Further evidence of the similarity of the Gunnedah and South Australian butterfly fauna is provided by this species, with further collecting other South Australian species may very possibly be found.

* Gunneda, place of white stone

Acknowledgments

My thanks go to many friends who have generously allowed me access to their collections and provided material for study, their help is acknowledged throughout these pages. David Crosby, F.R.E.S., kindly sent me all his Victorian *H. cordace* for extended study.

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Fig. 3

Fig. 4

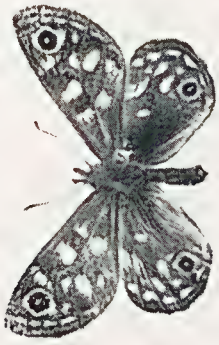

Fig. 5

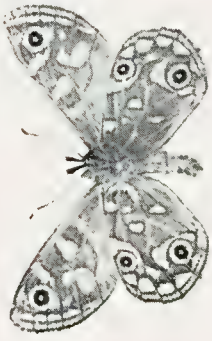

Fig. 6

Fig. 1

Fig. 2

Fig. 1, 2.—Geyer's figures of "*Tisiphone cordace*". (Courtesy of the Trustees of the Brit. Mus. (Nat. Hist.) and Mr. W. H. T. Tams.)

Fig. 3, 4.—*Heteronympha cordace comptena* n. ssp. Allotype female, Strahan, Tasmania. Sea level. 23 January, 1950. L. E. Couchman.

Fig. 5, 6.—*Oreixenica ptunarra ptunarra* Couchman, 1953. Holotype male, Miena, Tasmania. 3300 feet. 1 March, 1952. R. Dobson.

(Figs. 3-6, A. M. Hewer.)

Two new Cestodes (Genus **Oochoristica**) one from the lizard, **Egernia whitii**, the other from the bat, **Nyctophilus geoffroyi**

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WITH 22 TEXT FIGURES

Summary

Two new species of *Oochoristica*, namely *O. vacuolata* n. sp. from the lizard, *Egernia whitii* and *O. nyctophili* n. sp. from the bat, *Nyctophilus geoffroyi* are described, and their affinities with other species discussed.

Literature on the genus, published since the review by Hughes (1940), is cited.

Introduction

Hitherto only one species of the genus *Oochoristica* has been recorded from Australia, namely *O. trachysauri* (MacCallum 1921) Baer 1927. This species was first described from an Australian lizard *Trachysaurus rugosus*, which died in the New York Zoological Park. Later, Johnston (1932) supplemented the original description with information on specimens found in *T. rugosus* in South Australia, New South Wales, Victoria and Southern Queensland. In view of this solitary record, Wardle (1951 p. 123) in commenting on the distribution of tapeworms in the Southern Pacific region (excluding South America and Antarctica) remarks, " Striking is the absence of the marsupial-favouring species of *Oochoristica* Lühe, so well represented among the South American opossums, and the occurrence of only one of the reptile-favouring species of this supposedly primitive genus ".

Furthermore, up to the present no cestode has been recorded from Tasmanian lizards. The discovery of two new species of *Oochoristica*, one, *O. vacuolata* in the lizard, *Egernia whitii* (Lacépède), the other, *O. nyctophili*, in the bat, *Nyctophilus geoffroyi* Leach, is therefore of interest. Descriptions of the new species are given hereunder.

Genus **Oochoristica** Lühe (1898, p. 652)

Diagnosis: Unbewaffnete Taenien, ohne rudimentäres Rostellum und ohne axialen Muskelzapfen, mit randständigen, unregelmässig abwechselnden Genitalöffnungen, deren Uterus eine sehr rasch erfolgende Umbildung erfährt, dergestalt, dass in reifen Proglottiden die Eier einzeln in das Parenchym eingebettet sind. Typische Art: *Oochoristica tuberculata* (Rud.).

Oochoristica vacuolata n. sp.

The following description is based on an examination of about thirty specimens. Twenty specimens were fixed in sublimate acetic. Of these some were stained in either alum carmine or haematoxylin and mounted whole, others were used for serial sections. Whole mounts were also made of compressed specimens fixed in 90% alcohol and stained.

Unless otherwise indicated, quantitative data relating to the type specimen are given in parentheses.

EXTERNAL MORPHOLOGY

The cestode is dorso-ventrally compressed. Mature worms fixed in sublimate acetic and preserved in 90% alcohol measure 8·2-53·0 (43·0) mm. long and 0·42-1·03 (1·02) mm. wide.

The scolex measures 285·0-405·0 (405·0) μ long and 225·0-375·0 (360·0) μ wide and has a dorso-ventral diameter of about 135·0 μ. It is rounded in front and bears four unarmed suckers, which in life, are directed anteriorly. They are situated laterally, so that on each side there is a dorsal and a ventral sucker. Each sucker is approximately circular and measures 101·0-160·0 (150·0) μ in diameter. The muscular wall forming the floor of the cavity of the sucker varies from 39·0 to 55·0 μ in thickness.

Behind the scolex there is usually a distinct neck 225·0-1050·0 (375·0) μ long, 165·0-300·0 (300·0) μ wide and about 103 μ thick.

The strobila, which increases in width and thickness from the neck to the posterior end, consists of 14-53 (47) proglottides. In relaxed specimens the segmentation is distinct but in contracted worms it becomes obscured by the development of secondary and tertiary folding of the cuticula. The segments are acraspid and increase in length towards the posterior. Immature proglottides are almost as broad as they are long, being 285·0-375·0 (360·0) μ in width and 300·0-390·0 (360·0) μ in length. They are about 140 μ thick. Mature segments (except when contracted) are longer than broad 400·0-1120·0 (1000·0) x 320·0-570·0 (570·0) μ. Gravid segments are always longer than broad and measure 570·0-4275·0 (1200·0-3600·0) μ long, 345·0-1025·0 (600·0-1020·0) μ wide and about 285 μ thick.

CUTICULA AND PARENCHYMA
(FIGURE 1)

The cuticula varies in thickness from 1 to 3 μ. It consists of three layers. There is an outer layer beset with numerous small projections. Underneath the outer layer is a thicker homogeneous layer. Inside this layer is the basement membrane. Hooks and spines appear to be absent.

Cortical and medullary parenchyma are recognisable. The outermost layer of the cortical parenchyma is composed, almost entirely of extremely large vacuolated cells. These cells are visible both in live specimens and in whole mounts. They attain their maximum size in mature and gravid segments. When the segments are extended the cells measure up to 62·0 μ in depth and 40·0 μ in diameter. They form a layer 40·0-62·0 μ in thickness. Owing to the development of large vacuoles the nuclei of these cells are situated excentrically and are closely applied to the walls of the cells.

Calcareous corpuscles are distributed throughout the parenchyma. They appear to be more numerous in the cortical parenchyma and outer parts of the medullary parenchyma than elsewhere. Their form is spherical to ovoid and their greatest diameter measures 4·6-9·2 μ. Young worms have a higher concentration of these corpuscles than do mature worms.

In the neck region the cortical parenchyma is approximately the same thickness as the medulla, that is to say the greatest distance from the cuticula to the transverse muscles is about the same as the maximum dorso-ventral distance between the two layers of the transverse muscles.

For both cortex and medulla the thickness ranges from 34·5 to 40·0 μ. However, in the region of the immature proglottides the thickness of the cortex varies from 46·5 to 57·5 μ and is only about two-thirds that of the medulla, which, in this region, varies from 69·0 to 80·5 μ. In mature and gravid proglottides the sub-cuticular cells enlarge causing the thickness of the cortex once more to approach that of the medulla. For example in the mature proglottides the thickness of the cortex varies from 57·5 to 80·5 μ and that of the medulla from 69·0 to 110·0 μ while in the gravid proglottides the thickness of the cortex varies from 80·5 to 115·0 μ and that of the medulla from 69·0 to 138·0 μ.

MUSCULAR SYSTEM
(FIGURE 1)

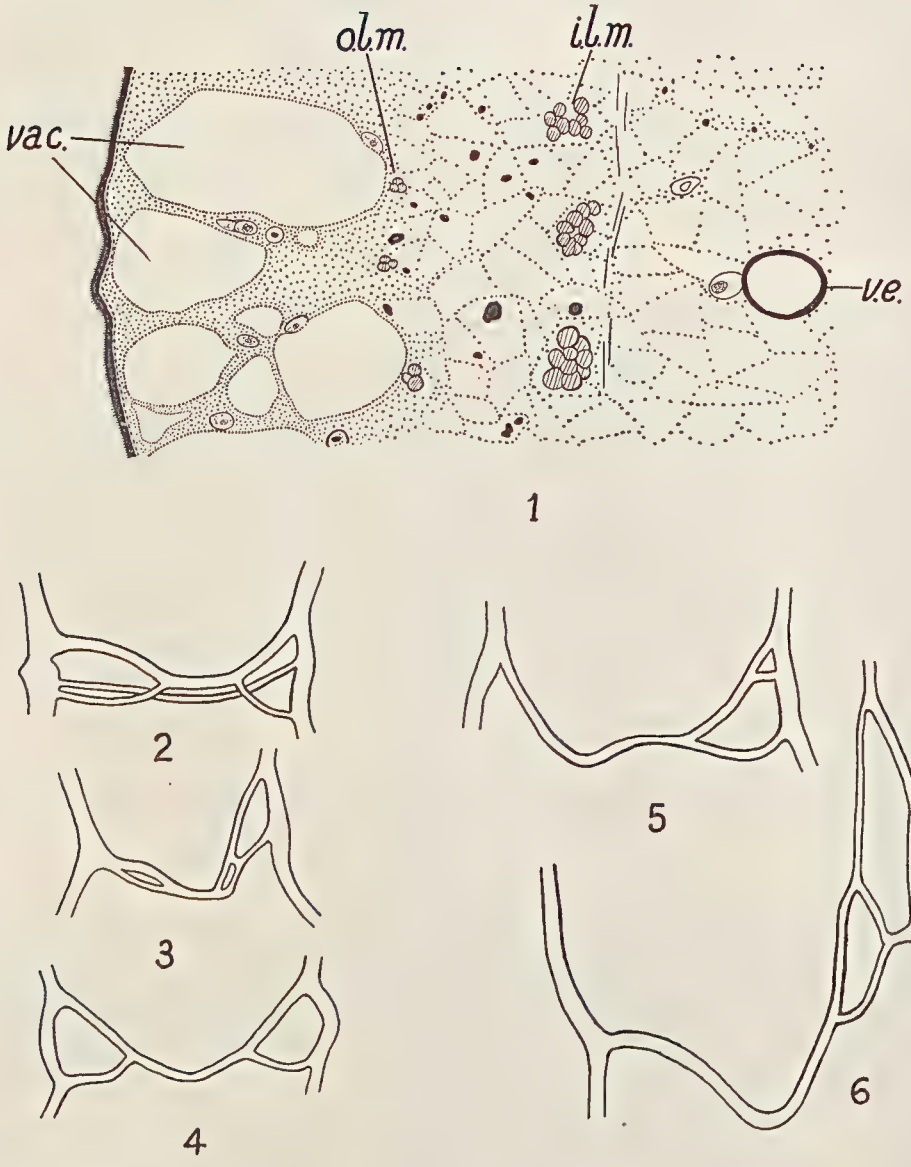
Immediately beneath the cuticula is a very thin layer of extremely fine fibres forming the subcuticular circular and longitudinal musculature.

There are two sets of longitudinal muscles in the cortex. The outer set is weakly developed consisting of single fibres, or bundles of two to four fibres, situated immediately beneath the large subcuticular cells. These fibres are most easily seen in mature segments. The inner set of longitudinal muscles is fairly well developed. It consists of 26-34 muscle bundles, separated from each other by distances up to 23·0 μ. The number of bundles in the dorsal half of the segment is generally the same as that in the ventral half. In mature segments the distance of the bundles from the cuticula measures 46·0-69·0 μ and in gravid segments 69·0-103·0 μ. Each bundle consists of 3-10 fibres. Bundles of eight contracted fibres measure 11·5-16·0 μ in diameter. The diameter of contracted fibres varies from 2·3 to 6·9 μ. The transverse and dorso-ventral muscles are poorly developed. They consist of very fine fibres which are not grouped into bundles.

No special musculature is associated with the genital atrium. The subcuticular musculature closes and opens the atrium.

EXCRETORY SYSTEM
(FIGURES 2-7)

In each lateral half of the strobila there is a dorsal longitudinal vessel and a ventral longitudinal vessel. These traverse the whole length of the worm and are situated in the medulla, $\frac{1}{4}$-$\frac{1}{3}$ the width of the strobila from the lateral margin. In the neck, the distance separating dorsal and ventral vessels from each other is about 16·0 μ and in the immature segments, about 20·0 μ. In the mature segments, the separation of the vessels is somewhat greater and more variable, averaging 29·0 μ. In the gravid proglottides the distance between dorsal and ventral vessels is 23·0-80·5 μ, the separation being greatest where the genital ducts pass between the two vessels. The diameter of the dorsal vessels measures 6·9-11·5 μ, whilst that of the ventral vessels 8·0-20·7 μ. In mature segments the average diameter of the dorsal vessel is 9·2 μ, that of the ventral vessel 11·5 μ. Near the posterior of each segment the ventral vessels are connected by a transverse vessel. In mature and gravid segments this transverse vessel is often curved posteriorly so that its connections with the ventral vessels are oblique. The diameter of the transverse vessel varies from 4·6 to 9·2 μ.



Oochoristica vacuolata n. sp.

Fig. 1.—Transverse section of body wall.
Figs. 2-6.—Variations in the connections between the transverse excretory vessel and the ventral longitudinal excretory vessels.

In the first formed proglottis the longitudinal vessels unite posteriorly in a common elongated vesicle which is surrounded by darkly staining cells and opens to the exterior through a median posterior pore. After the casting off of this proglottis the longitudinal vessels may open separately or the dorsal vessel of each side may unite with the ventral vessel of the same side to form a small posterior vesicle, which opens to the exterior. Between the anterior limits of the suckers the dorsal and ventral vessels on each side unite. In a specimen whose scolex measures 253·0 μ in width, the union of the vessels occurs at 70·0 μ from the anterior margin. The two vessels so formed have a diameter of 6·9 μ. They pass anteriorly for a distance of 20·0 μ and then join in a transverse loop. This loop is situated at about 50·0 μ from the anterior margin of the scolex.

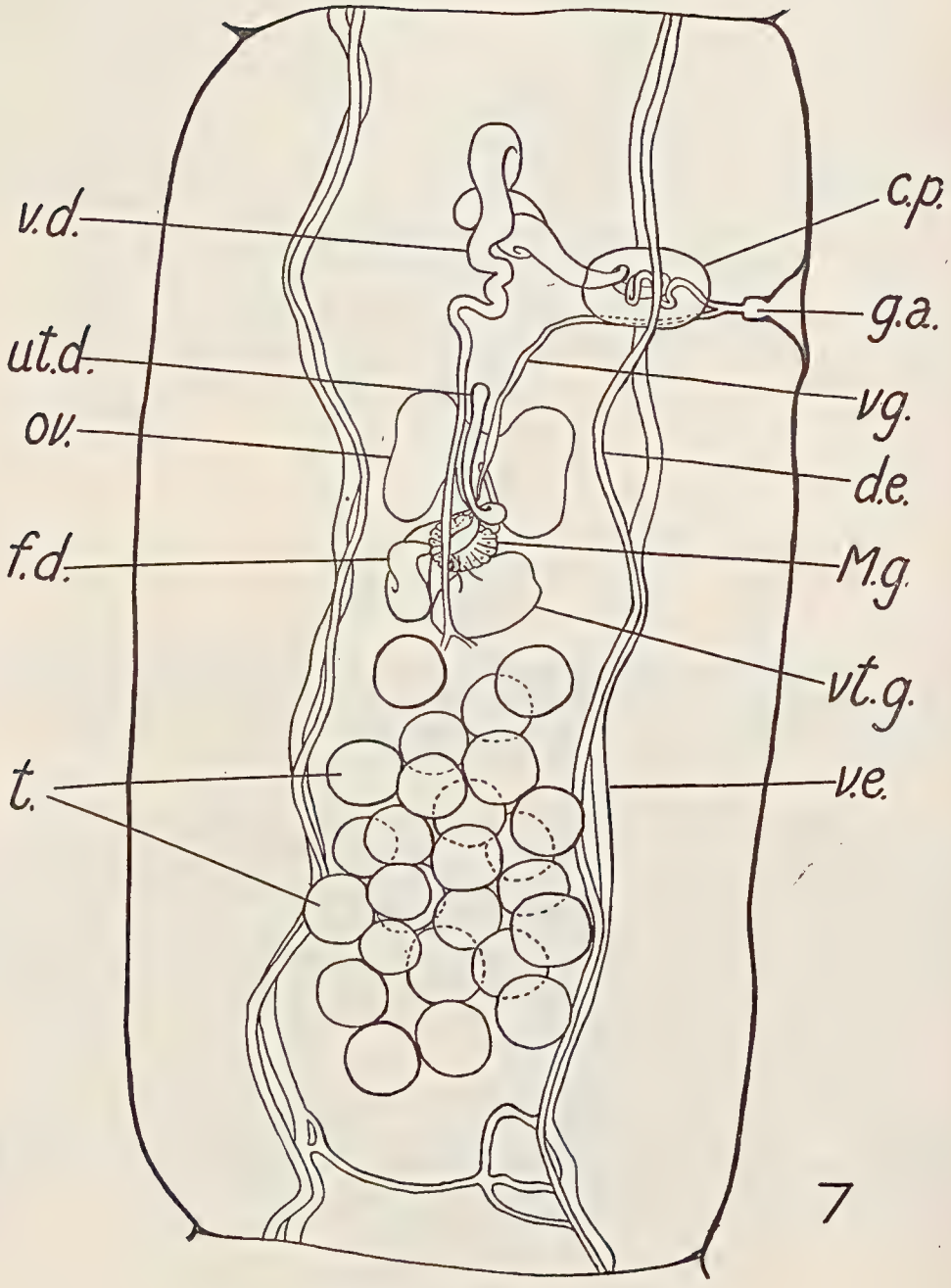
Irregularities such as duplication of parts of the main vessels, are common, especially in the scolex and at the connections with the transverse vessels.

NERVOUS SYSTEM

The two main lateral nerves have diameters of 11·5-13·8 μ and traverse the entire length of the strobila external to the excretory vessels but inside the medulla. The distance of the nerves from the lateral margin measures 3/20-3/11 the width of the strobila.

The nervous system of the scolex consists of two lateral ganglia which are connected dorsally with a median dorsal ganglion and ventrally with a median ventral ganglion. The lateral ganglia are connected by a narrow transverse commissure which passes between the dorsal and ventral excretory vessels, just posterior to the union of the latter. The lateral ganglia measure 23·0-34·5 μ in diameter. They are situated about 69 μ apart, between and slightly internal to the dorsal and ventral suckers of each side. The lateral nerves arise from these ganglia and diverge towards the margins of the strobila.

The dorsal and ventral ganglia are situated between the dorsal and ventral suckers respectively. They are rather smaller than the lateral ganglia and measure 18·4-23·0 μ in diameter. Slender dorsal and ventral nerves arise from these two ganglia. The transverse commissure linking the lateral ganglia has a diameter of about 4·6 μ.



Oochoristica vacuolata n.sp.
FIG. 7.—Dorsal view of mature proglottis.

REPRODUCTIVE SYSTEM
(FIGURES 7-11)

The primordium of the reproductive system appears 0·65-1·5 (0·9) mm. from the anterior end of the scolex and within the first four proglottides. It has the form of a mass of centrally-placed darkly staining cells, from which, in the succeeding segments, the ovary and vitelline gland are developed. The former is situated anterior to the latter. Within segments 8-10 (10), 1·8-2·4 (1·8) mm. from the anterior end of the worm, a transversely elongated group of cells appears to the left or right of the anterior of the ovary. This group of cells gives rise to both the vagina and the vas deferens. In the same region of the worm but posterior to the female glands the testes appear. Within the following five to eighteen segments the ovary becomes clearly bilobed, the vitelline gland is seen as a distinct structure, the testes mature and the genital ducts become visible. Finally the uterus and Mehlis's gland appear. Maturity is attained within segments 14-31 (29-31), 3·1-11·0 (11·0) mm. from the anterior end of the worm. The uterus develops rapidly and resolves itself into numerous uniovulate capsules which gradually become scattered through the medullary parenchyma of the segments posterior to those that are mature. With the growth of the uterus, other organs begin to degenerate. The testes are first to disappear and are followed by the ovary and vitelline gland. Next, the vagina and vas deferens degenerate and finally the cirrus pouch. Within segments 22-40 (40), 22·5-25·0 (25·0) mm. from the anterior end of the worm onchospheres are developed.

The common genital pores are situated laterally and alternate irregularly. The distance of the pore from the anterior margin of the proglottis varies from $\frac{1}{6}$ to $\frac{1}{4}$ ($\frac{1}{5}$-$\frac{1}{4}$) the length of the proglottis. There is often a slight protuberance of the margin surrounding the pore. Inside the pore the atrium measures 13·8-20·7 μ in diameter and 9·2-18·4 μ in depth. The atrium which has a cuticular lining is surrounded by darkly staining cells. It appears to lack any particular musculature. Opening into the inner end of the atrium in mature and gravid segments is a small common canal (fig. 8). In immature segments the opening is closed by the cuticular lining of the atrium. The canal communicates with the poral end of the transversely elongated cirrus pouch. It is thin walled and measures 29·9-32·2 μ in length and 2·3-4·6 μ in diameter. The vagina joins the canal ventrally at 18·4 μ from the atrium.

Female

The ovary is bilobed and its two lobes are not subdivided. In the mature region of the strobila the distance of the front of the ovary from the front of the proglottis is $\frac{1}{4}$ to $\frac{1}{3}$ (7/24) the length of the segment. The ovarian bridge is either central or slightly poral to the midline and unites the anterior ventral parts of the ovarian lobes. It has a diameter of 23·0-34·5 μ. The ovary is 96·6-184·0 μ wide and 46·0-80·5 μ thick. The width of the aporal lobe measured from the ovarian bridge to the lateral margin of the lobe varies from 48·3 to 92·0 (75·0-90·0) μ and is generally slightly greater than that of the poral lobe which varies from 46·0 to 92·0 (75·0-82·0) μ. Sometimes the lobes are equal in width but rarely is the poral wider than the aporal lobe. The lobes are seldom equal in length, one lobe being nearly always slightly longer than the other. The

length of the poral lobe measures 36·8-138·0 (105·8-120·0) μ and that of the aporal lobe 48·3-120·0 (105·0-120·0) μ. Usually the aporal lobe is closer to the anterior of the proglottis than is the poral lobe.

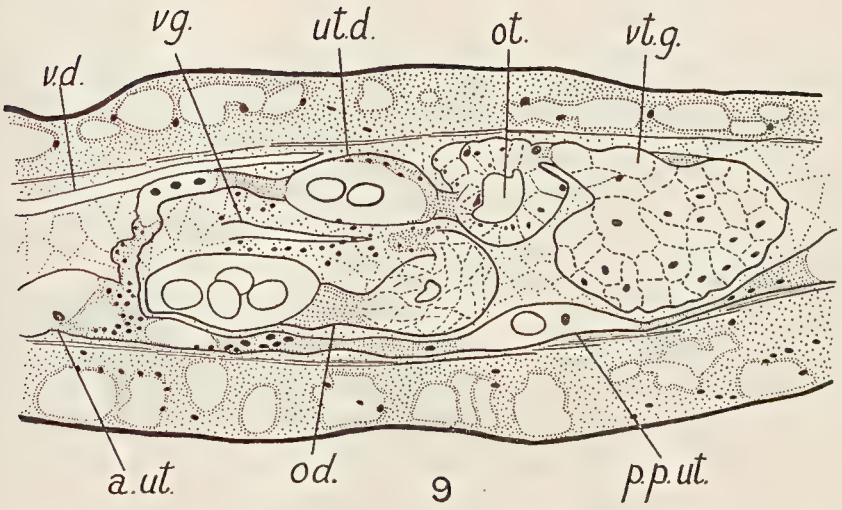
The vitelline gland is situated posterior to the ovary and near the middle of the segment. In extended proglottides the distance from the anterior margin of the ovary to the posterior margin of the vitelline gland measures 225·0-255·0 μ. The distance from the posterior of the ovarian bridge to the anterior of the vitelline gland varies from 73·6-103·5 μ. The vitelline gland is variable in shape but always compact and usually broader than long, 36·8-98·9 (75·0-90·0) x 32·2-92·0 (75·0-90·0) μ. It has a dorso-ventral diameter of 46·0-80·5 μ.

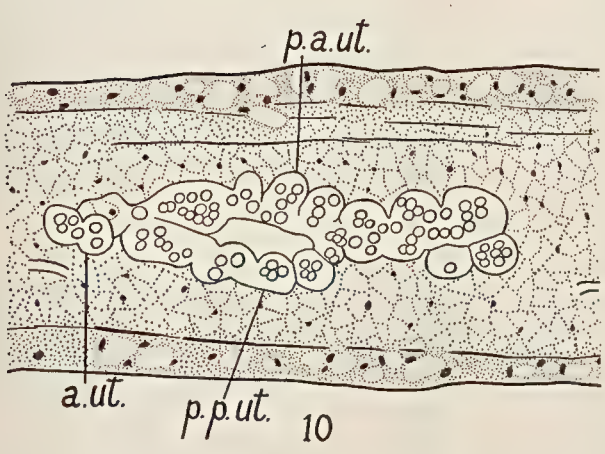
Mehlis's gland is situated dorso-anteriorly to the vitelline gland. It has a diameter of 23·0-36·8 (34·5) μ.

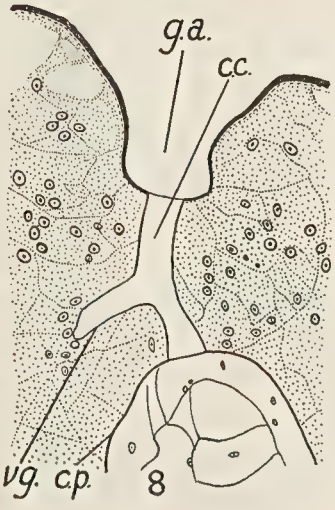
On leaving the vaginal pore the vagina, which seems to be lined with cilia, passes inwards as a narrow duct 2·3 μ in diameter. A sphincter muscle is absent. The vagina either passes directly inwards along the postero-ventral side of the cirrus pouch or curves forward beneath the pouch to pass inwards along its antero-ventral side. In either case it passes dorsal to the lateral nerve and either between or dorsal to the poral excretory vessels. On reaching the inner end of the pouch it curves in a wide arc towards the ovarian bridge. Some distance in front of the ovary the vagina forms a somewhat elongated receptaculum 80·5-92·0 μ in length. The width of the receptaculum is variable and depends to some extent on the presence or absence of sperms in the lumen. The posterior end of the receptaculum which may measure 16·1 μ in diameter passes over the ovarian bridge, sometimes slightly to the poral side. From here the vagina narrows, bends ventrally and enters the oviduct.

The oviduct arises ventrally from the ovary in the region of the bridge. It passes back between the lobes of the ovary for a distance of about 51·7 μ. A muscular oocapt is absent. However, at a distance of about 46 μ from the ovarian bridge there is a marked constriction of the wall of the oviduct. A short distance beyond this constriction, the oviduct bends back on itself dorsally and passes forward in an antero-dorsal direction for a distance of approximately 28·7 μ. At this point it is joined by the vagina. That part of the oviduct preceding and including the constriction is thin-walled. Beyond the constriction the wall of the duct increases in thickness and the duct measures about 27·6 μ in diameter. Following its junction with the vagina the duct continues as the fertilization canal and immediately folds back on itself dorsally. It passes back in a postero-ventral direction and may curve to either side so as to pass between the front of the vitelline gland and either the poral or aporal lobe of the ovary. After traversing a distance of about 92·0 μ, the canal bends back dorsally on itself to pass forwards and then inwards towards Mehlis's gland which it penetrates from behind and below. The ferilization canal has a thick wall like that of the oviduct. Its diameter also is about 27·6 μ.

The vitelline duct arises from the dorsal aspect of the vitelline gland and passes anteriorly to enter Mehlis's gland from behind. It has a diameter of 6·9-18·4 μ.







Oochoristica vacuolata n.sp.

FIG. 8.—Part of transverse section through a mature proglottis in the region of the genital atrium.

FIG. 9.—Paramedial section through a semigravid proglottis.

FIG. 10.—Horizontal section through the ventral medulla of a semigravid proglottis showing the uterus.

Inside Mehlis's gland the vitelline duct unites with the fertilization canal to form an ootype. The ootype is spherical or ovoid in shape, 13·8-29·9 μ in diameter.

The uterine duct arises from the anterior of the ootype and passes forward ventrally to the vas deferens and dorsally to the oviduct, receptaculum and ovarian bridge. As it passes forward its course becomes rather sinuous. Immediately in front of the ovary the duct curves ventrally, aporal to the vagina (receptaculum) and passes to the anterior ventral side of the ovary where it enters the uterus. The uterine duct has a diameter of 11·5 μ except near Mehlis's gland where it may measure 23·0-34·5 μ wide. The wall consists of a single layer of flat cells. From the place of entrance of the uterine duct, the uterus spreads out anteriorly and posteriorly. Initially the uterus has a short median anterior prolongation and a pair of longer posterior outgrowths. The latter pass ventrally to the lobes of the ovary on either side of the midline and merge with each other ventrally and posteriorly to the vitelline gland (fig. 10). At this stage the uterus consists of a series of cavities which are in communication with each other and which have a dorso-ventral diameter of about 11·5 μ. The eggs pass forward through the uterine duct into the cavities of the uterus. As the uterus fills with eggs it grows rapidly towards the anterior and posterior of the proglottis to fill the entire ventral part of the medulla. It then develops numerous branches which pass upwards between the degenerating genital organs. Finally the uterus appears to resolve itself into a large number of uniovulate capsules. These capsules vary in shape from spherical to ovoid and measure 52·9-87·4 $\times$ 34·5-57·5 μ. In the posterior gravid segments each onchosphere is surrounded by two membranes. The outer membrane is thin and irregularly shaped, whilst the inner membrane (embryophore) is thick and oval. The embryophore measures 37·9-46·0 $\times$ 32·2-39·1 μ and contains an oval onchosphere 34·5-41·1 $\times$ 27·6-34·5 μ. The hooks of the onchosphere vary in length from 18·4 to 25·0 μ.

Male.

The testes are situated in the medulla of the posterior half of the proglottis, some being disposed dorsally, others ventrally, the upper ones frequently overlapping the lower ones. They lie between the lateral nerve cords and may occur on each side of the vitelline gland. However, they do not extend above, below or in front of this gland. The number of testes in any one proglottis varies from 19 to 45, the most usual number being 33. They are clearly distinguishable in 5 to 18 segments. The testes are generally spherical and measure 25·3-69·0 μ in diameter. In mature proglottides they are commonly 46·0-57·5 μ in diameter. They increase in size as they discharge the sperms, and attain their maximum size in semi-gravid proglottides. The vasa efferentia from the testes join up and form two main ducts. These unite above the vitelline gland and form the vas deferens, which passes forward dorsally to the ovary. It generally lies slightly aporal to and above the uterine duct, receptaculum and ovarian bridge, where it has a diameter of 4·6-6·9 μ. At about the level of the cirrus pouch and atrium it becomes highly convoluted and its diameter increases to

about 18·4 μ. Here its wall measures 6·9-9·2 μ in thickness and is composed of a single layer of very large cells. The nuclei of these cells are of remarkable size, measuring 2·3-4·6 μ in diameter. This part of the vas deferens is usually filled with spermatoza and appears to function as a vesicula seminalis. After forming about 7 loops it enters the cirrus pouch. Within the pouch it forms 3-5 loops and then decreases in diameter giving rise to a thin walled unarmed cirrus. The latter measures about 36·8 μ long and has a diameter of 3·4 μ. When everted, the cirrus protrudes through the short common canal leading to the genital atrium. The cirrus pouch has a thin muscular wall and varies from 46·0 to 69·0 (46·0) μ in diameter. It has a length of 73·6-119·6 (87·4) μ and lies above the poral longitudinal nerve. In mature segments it extends either above or between and beyond the poral excretory vessels for a distance of about half its length, but in gravid segments it barely reaches the excretory vessels. A retractor muscle to the cirrus pouch is absent.

Type host: Egernia whitii (Lacépède).

Type locality: Domain, Hobart.

Type specimen: In Department of Zoology, University of Tasmania.

Affinities of *O. vacuolata* n. sp.

Hughes (1940) in a review of the genus of *Oochoristica* lists 28 species from reptilian hosts. Hughes, Baker and Dawson (1941) record 30 species from reptiles. Four other species, one subspecies and one variety, all from reptiles, may now be added to the list. They are as follows: *O. africana* Malan (1939) from *Agama hispida* var. *distans*, *O. africana* var. *ookiepensis* Malan (1939) from *Scaptira knoxi*, *O. anniellae* Stunkard and Lynch (1944) from *Anniella pulchra nigra*, *O. indica* Misra (1945) from *Calotes versicolor*, *O. scelopori* Voge and Fox (1950) from *Sceloporus occidentalis occidentalis* and *O. amphisbeteta junkea* Johri (1950) from *Gecko gecko*.

In reference to *O. amphisbeteta junkea*, which Johri records from a reptile, it may be pointed out that *O. amphisbeteta* was originally recorded by Meggitt (1924) from a mammal. It seems very unlikely that the same species of cestode occurs in such different hosts and one may doubt whether the form described by Johri is assignable to *O. amphisbeteta*.

The tapeworm described in the present paper brings the total species of *Oochoristica* recorded from reptiles to 35. Unfortunately the descriptions of many of the species are incomplete and frequently limited to quantitative characters. As a result it is often difficult satisfactorily to distinguish species.

When compared with those species which have been adequately described, *O. vacuolata* n. sp. is seen to resemble *O. trachysauri* (MacCallum 1921) as described by Johnston (1932). However, it differs from *O. trachysauri* in the position and development of the uterus, the presence of a constriction of the oviduct, the form of the ovarian lobes and the absence of special musculature of the atrium. Moreover, the

genital ducts of *O. vacuolata* n. sp. do not open independently into the atrium, but by way of a short common canal. The size of the worm, scolex and suckers, the dimensions of the cirrus pouch, the size and number of the testes and the size of the ovary, vitelline gland, eggs and onchosphres are quantitative characters in which the new species often differs from other members of the genus.

The specific name *vacuolata* was suggested by the vacuolated nature of the subcuticular cells.

Infestation of Host.

Sixty specimens of the lizard, *Egernia whitii* were examined. Of these 55 came from the Domain, near Hobart, 2 from Mt. Nelson and 3 from Cooee, near Burnie. Forty of the specimens were found to be infested and all of these were from the Domain.

The cestode was generally present in the anterior part of the small intestine and attached to the wall a short distance from the pyloric valve. In some cases, however, the tapeworm was attached further away from the pyloric valve and the posterior proglottides extended into the rectum. Starvation of the host for about a fortnight caused the cestodes to undergo marked destrobilization. Of the forty lizards harbouring the tapeworm 19 were males and 21 were females. The intensity of infestation varied from 1-16 worms per host.

The following table shows the relative frequency of infestation of the sexes correlated with intensity of infestation.

Number of Worms		1	2	3	4	5	6	7	9	12	14	16
Number of Lizards infested	Male	4	2	3	1	1	1	2	1	2	1	1
	Female	2	3	6	1	3	2	1	1	0	1	1

From the above table it may be seen that the lizards showed no evidence of sex resistance to infestation. The lizards varied in size but no correlation between size and intensity of infestation was evident.

The total number of cestodes found was 212.

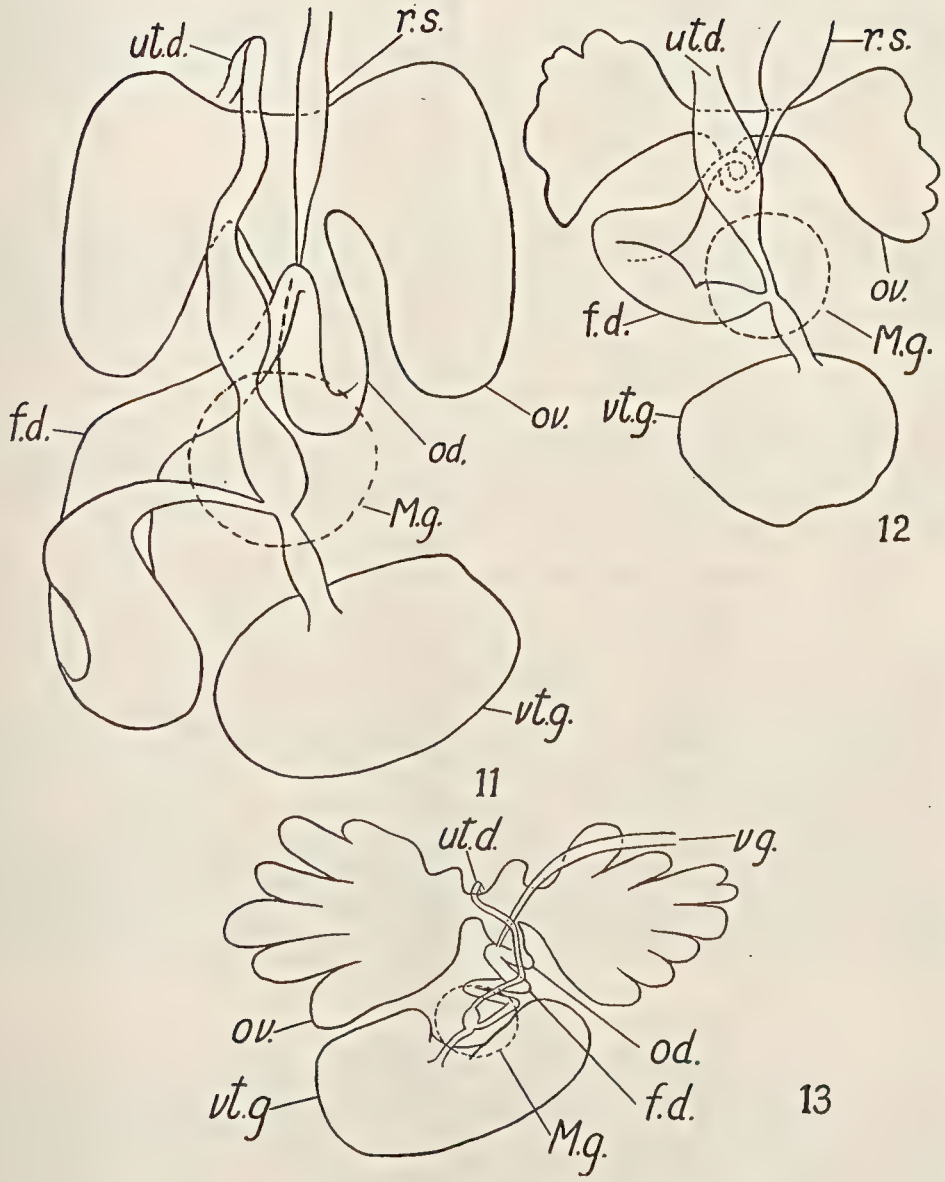
Oochoristica nyctophili n. sp.

The following description is based on three specimens, two of which are complete and one lacks the scolex and some of the anterior segments of the strobila. The worms were fixed in sublimate acetic and sectioned at 8-10 μ.

Unless otherwise indicated, quantitative data relating to the type specimen are given in parentheses.

EXTERNAL MORPHOLOGY.

The mature worm is 11-31+ (28) mm. long and has a maximum width of 0·975-1·65 (0·975) mm. It is dorsoventrally compressed, having a maximum thickness of 345·0-420·0 (360·0) μ.



Oochoristica vacuolata n.sp.

FIG. 11.—Ovary and associated organs in dorsal view.

Oochoristica trachysauri (MacCallum)

FIG. 12.—Ovary and associated organs in dorsal view. (After Johnston, 1932, p. 66, fig. 7.)

Oochoristica nyctophili n. sp.

FIG. 13.—Ovary and associated organs in dorsal view.

The scolex is rounded in front and bears four unarmed suckers. It measures 207·0-270·0 (207·0) μ in width and has a dorso-ventral diameter of 168·0-195·0 (168·0) μ. The suckers are situated laterally so that on each side there is a dorsal and a ventral sucker. They are cup-shaped and oval, measuring 100·0-115·0 $\times$ 64·5-80·5 (100·0-115·0 $\times$ 64·5-73·6) μ. The depth of the cavity of the sucker varies from 36·8 to 55·2 (36·8-48·3) μ and the muscular wall at the bottom of the cavity is 23·0 μ thick.

The strobila increases in width and thickness from the neck to the posterior end. The segmentation is distinct, the strobila consisting of 40-46 (46) segments. In relaxed specimens the segments are acraspid and increase in length towards the posterior. The anterior segments are broader than long but the posterior segments are longer than broad.

CUTICULA AND PARENCHYMA. (FIGURE 14)

The cuticula varies in thickness from 2·3 to 3·4 μ. It consists of three layers, an outer comidial layer, a central homogeneous layer which constitutes the greatest portion of the cuticula, and a basement membrane.

Hooks and spines are absent.

The cortex and medulla are quite distinct. Immediately beneath the basement membrane the cortex consists of numerous cells which are closely packed and elongated at right angles to the basement membrane.

Nearer the medulla the cortex consists of a smaller number of cells, more loosely packed and forming a meshwork. The cortex varies in thickness from 69·0 to 92·0 μ.

The cells of the medulla also form a meshwork. As the segments mature the medulla increases in thickness from 80·0 μ in immature segments to 172·0 μ in gravid segments. However, in a contracted mature segment the medulla measured 200·0 μ thick. No calcareous corpuscles were observed. However, they may have been removed by the fixative.

MUSCULAR SYSTEM (FIGURE 14)

Situated immediately beneath the basement membrane is the sub-cuticular circular and longitudinal musculature. It is composed of extremely fine fibres. There are two sets of longitudinal muscles in the cortex. The outer set consists of separate fibres and bundles of 2 to 6 fibres scattered in the meshwork of the cortical parenchyma. The largest bundles are found nearest the medulla. The fibres are each about 2·3 μ in diameter and a bundle of six such fibres measures 9·2 μ in diameter. The inner set consists of a single layer of 35-50 muscle bundles surrounding the medulla. Each bundle is composed of 2 to 10 fibres. The fibres measure 2·3 to 3·5 μ in diameter. The bundles of fibres are frequently dorso-ventrally compressed and a bundle of six fibres measures 13·8 μ in diameter.

The transverse musculature (circular musculature) which separates the cortex from the medulla consists of separate fibres. These fibres appear intermingled with the inner longitudinal muscle bundles. There is a well-developed dorso-ventral musculature consisting of separate fibres which pass either through the medulla from the dorsal to the ventral transverse muscles or to the genital organs situated in the medulla.

EXCRETORY SYSTEM
(FIGURE 15)

In each lateral half of the medulla there is a dorsal and a ventral longitudinal vessel. These traverse the whole length of the strobila. The dorsal vessels are very narrow and in mature proglottides have a diameter of 4·0 μ. They are frequently linked with the ventral vessel of the same side by short dorso-ventral vessels. The diameter of the ventral vessels is very variable and in mature segments averages 9·2μ. The vessels occasionally anastomose and in each segment they are linked by 2 or more transverse vessels. The separation of the dorsal and the ventral vessels of the same side and the distance of the ventral vessel from the lateral margin of the strobila vary considerably.

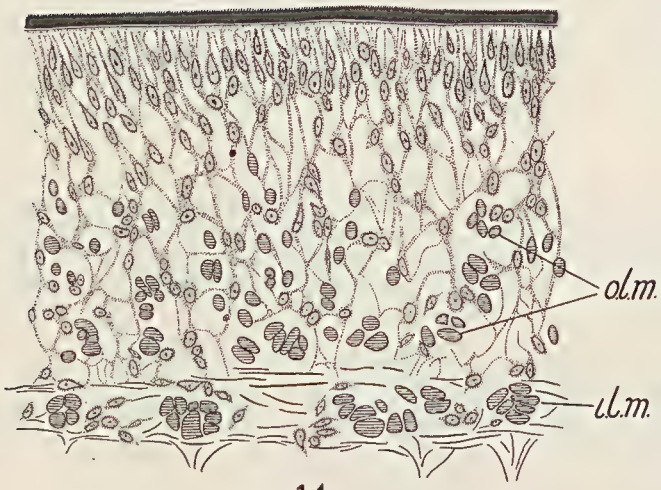
In the scolex the dorsal vessel and the ventral vessel on each side unite and the two vessels so formed pass forwards to join in a transverse loop situated 60 μ from the anterior margin of the scolex.

NERVOUS SYSTEM

In the scolex there is a small ganglion at the base of each sucker and a larger ganglion between the dorsal and ventral sucker of each side. The small ganglia measure 13·8 μ and the larger lateral ganglia 23·0 μ in diameter. These ganglia are joined together to form a nerve ring. In addition, the lateral ganglia are joined by a transverse commissure which passes between the dorsal and ventral excretory vessels of each side. This transverse commissure has a diameter of 4·6 μ. From each lateral ganglion a stout nerve passes posteriorly through the whole length of the strobila. These lateral nerves which measure 13·8 to 23·0 μ in diameter are situated just inside the medulla, 85·0 to 110·0 μ in from the lateral margin of the strobila.

REPRODUCTIVE SYSTEM
(FIGURES 13, 15-22)

In the centre of segment 2, about 600 μ from the anterior of the worm, the primordium of the ovary and vitelline gland appears. In segment 11-13 (11), 1·4-1·7 (1·7) mm. from the anterior of the scolex, the cells destined to form the vagina and vas deferens appear to the left and right of the anterior of the developing ovary. Posterior to the female glands in segment 12-14 (12) and 1·5-1·9 (1·9) mm. from the anterior of the worm, the testes appear. In segment 16-18 (16), 2·3-2·6 (2·6) mm. from the anterior of the scolex, the ovary, vitelline gland, vagina, uterine duct, testes, vas deferens, and cirrus pouch are all distinguishable.



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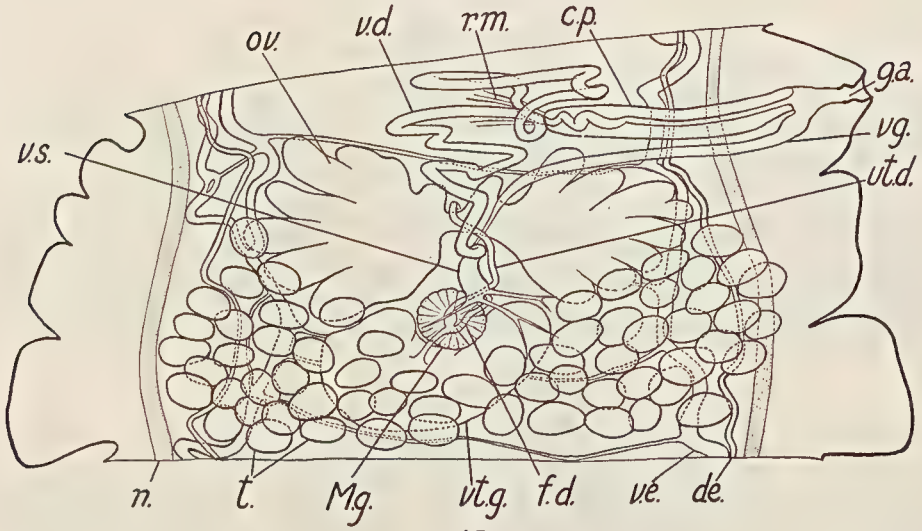

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Oochoristica nyctophili n.sp.

FIG. 14.—Transverse section of body wall.
FIG. 15.—Dorsal view of a mature proglottis reconstructed from a series of horizontal sections.

Although the uterus and Mehlis's gland are evident in segment 21-23 (21), 3·2-4·0 (4·0) mm. from the anterior of the worm, maturity is not attained until segments 25-31 (25, 26) at a distance of 5·6-5·7 (5·7) mm. from the anterior of the scolex. In the succeeding segments eggs pass into the uterus and the genital organs degenerate. As the uterus fills with eggs it rapidly resolves itself into a large number of uniovulate capsules which fill the entire medulla of gravid segments. In the type specimen, onchospheres are present in segments 41-46, 18·7-28·0 mm. from the anterior of the worm.

Mature segments are broader than long 690·0-1000·0 × 610·0-338·0 (810·0 × 338·0) μ. The common genital pores are situated laterally and alternate irregularly. The distance of the pore from the anterior margin of the proglottis is 1/8-1/4 (1/8) the length of the proglottis. There is often a slight protuberance of the margin surrounding the pore.

The genital atrium measures 15·0-30·0 μ deep and 9-15 μ in diameter. It has a thick cuticular wall and is surrounded by a dense mass of darkly staining cells. It appears to lack special musculature. Opening into the inner end of the atrium, in mature and gravid segments, is a wide thin-walled common canal. In immature segments the opening is closed by the cuticular lining of the atrium. The canal communicates with the poral end of the transversely elongated cirrus pouch. It measures 45·0-66·0 × 9·0-48·0 (57·5 × 11·5) μ. The vagina joins the inner end of the canal behind or below the male pore (figs. 17 and 18).

Female

The ovary is bilobed and measures 345·0-450·0 (435·0) μ wide and 120·0-190·0 (190·0) μ thick. The distance of the front of the ovary from the anterior of the proglottis is 1/7-1/4 (1/7) the length of the proglottis. Uniting the anterior ventral parts of the main lobes of the ovary is a narrow ovarian bridge about 70 μ in diameter. This bridge is situated on the longitudinal axis of the proglottis. The poral lobe of the ovary measures 165·0-225·0 (225·0) μ wide and 105·0-260·0 (150·0) μ long. It is generally only slightly smaller than the aporal lobe which measures 190·0-225·0 (210·0) μ wide and 120·0-260·0 (165·0) μ long. Each lobe is further subdivided into five or six finger-like lobules.

The vitelline gland is situated posterior to the ovary and just posterior to the centre of the segment. The distance between the posterior of the ovarian bridge and the anterior of the vitelline gland is 60·0-150·0 (60·0) μ. In horizontal sections of mature segments the vitelline gland appears kidney-shaped with its concavity anterior. It is also notched dorsally. The gland is compact and broader than long measuring 250·0-285·0 (285·0) × 120·0-200·0 (150·0) μ. It has a dorso-ventral diameter of 105·0-140·0 (140·0) μ.

Mehlis's gland is situated dorsal and slightly anterior to the vitelline gland. It has a diameter of 46·0-69·0 (69·0) μ.

Surrounding the poral end of the vagina is a well-developed sphincter muscle (figs. 17 and 18). From here, the vagina, which has a diameter of 9·2-23·0 (11·5) μ passes inwards along either the posterior or postero-ventral side of the cirrus pouch. It passes dorsal to the lateral nerve

and either dorsal to or between the poral excretory vessels. On reaching the inner end of the cirrus pouch it narrows and curves in a wide arc towards the ovarian bridge. Throughout its length the vagina is surrounded by darkly staining gland cells. It decreases in diameter, passes over the ovarian bridge slightly to the poral side, and enters the oviduct. A receptaculum seminis is absent.

The oviduct arises from the postero-ventral aspect of the ovarian bridge and passes back ventrally for a distance of 69·0-92·0 (69·0) μ. The first part of the duct is surrounded by numerous long-necked gland cells and a muscular thickening of its wall forms a conspicuous oocapt (figs. 19 and 20). Beyond the oocapt the oviduct has a thick non-muscular wall (fig. 21). It bends back on itself dorsally and passes in an antero-dorsal direction for a distance of 69·0-92·0 (69·0) μ. Except in the vicinity of the oocapt, the oviduct has a diameter of 20·7-23·0 (20·7) μ. As it approaches the postero-dorsal aspect of the ovarian bridge its diameter decreases slightly and at this point it is joined by the vagina.

It now continues as the fertilization canal and once more bends back on itself dorsally to pass in a postero-ventral direction towards the vitelline gland. After traversing a distance of 69·0-92·0 (69·0) μ it reaches the antero-ventral aspect of the vitelline gland and then curves dorsally, becoming narrow and penetrating the poral or aporal side of Mehlis's gland. The fertilization canal, like the oviduct, has a thick non-muscular wall and throughout the greater part of its course has a diameter of 16·1-20·7 (16·1) μ. In mature segments this canal is full of sperms. Sperms also occur in that part of the oviduct extending from the oocapt to the entrance of the vagina.

The vitelline duct arises from the dorsal notch of the vitelline gland and passes dorsally and then anteriorly to enter Mehlis's gland from behind. This duct, which is surrounded by darkly staining cells has a diameter of 6·9-11·5 (11·5) μ. In immature proglottides the vitelline duct appears to arise from the gland as two short ducts which immediately unite. Inside Mehlis's gland the vitelline duct unites with the fertilization canal to form a thin-walled ootype.

The ootype which is ovoid in shape, measures 20·0-23·0 (20·7) $\times$ 11·5-25·0 (13·8) μ and is surrounded by the ill-defined cells of Mehlis's gland.

The uterine duct arises from the anterior of the ootype and passes forwards ventral or lateral to the vas deferens but above the oviduct, vagina and ovarian bridge. It has a diameter of 13·8-16·1 (16·1) μ and its wall is composed of a single layer of flat cells. As it proceeds anteriorly its course becomes somewhat sinuous. In front of the ovarian bridge, the duct curves ventrally, passes down on the aporal side of the vagina and enters the uterus antero-ventrally to the ovary (fig. 16).

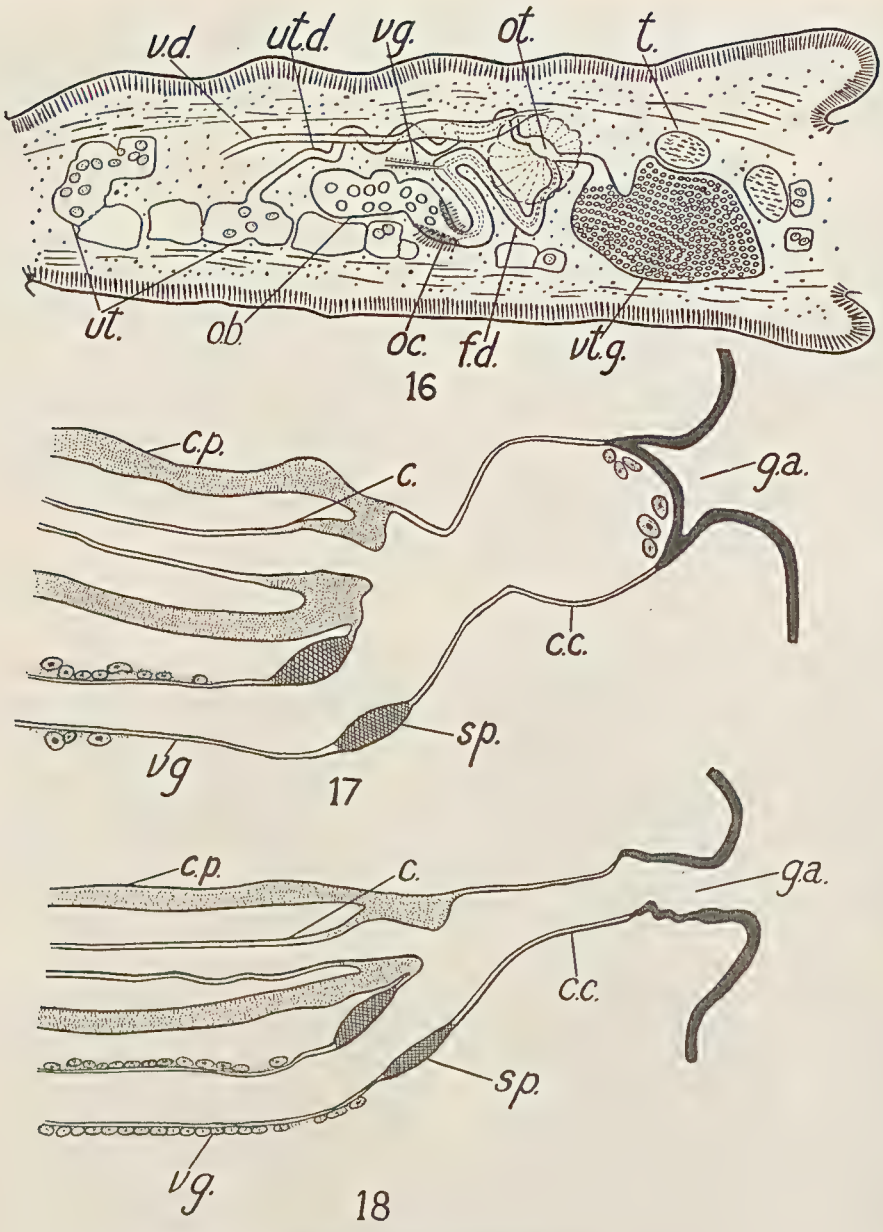
The uterus develops in the ventral part of the medulla, beneath the cirrus sac, vas deferens, vagina, ovary, vitelline gland and testes. Its wall is very thin and appears to consist of a single layer of cells. The early stages in the growth of uterus were not observed. However, in

the mature and semigravid segments the uterus appears as a series of cavities in the ventral part of the medulla. These cavities are in communication with each other and have a dorso-ventral diameter of 6·9-34·5 μ. The fertilized ova pass along the uterine duct and enter these cavities. As the uterus fills with eggs it develops numerous branches which pass upwards between the degenerating genital organs. Finally it appears to resolve itself into irregularly shaped capsules each containing a single egg. These uterine capsules are oval or spherical 36·8-57·5 × 25·3-57·5 μ. In the posterior gravid segments each onchosphere is surrounded by two membranes. Between the uterine capsule and the thin outer membrane of the egg is a darkly staining cellular mass. This mass appears either as an internal thickening of the uterine capsule or as an external thickening of the outer membrane. The outer membrane forms an irregularly-shaped thin walled capsule enclosing a slightly thicker inner membrane (or embryophore) which in turn encloses the onchosphere (fig. 22). The embryophore and onchosphere are spherical or slightly oval. The diameter of the former measures 16·2-20·7 μ and that of the latter 14·9-18·4 μ. The hooks of the onchosphere are 11·5-13·8 μ long.

Male

The testes are situated in the medulla of the posterior half of the proglottis. They are arranged in two to three rather indefinite layers posterior and lateral to the vitelline gland and lateral to the ovary. However, they never extend anteriorly beyond the level of the ovarian bridge. They overlie the posterior of the vitelline gland, and occasionally overlap the ends of the lobules of the ovary. They never extend ventrally to either the vitelline gland or ovary. A total of 64 testes were counted in a mature segment of the type specimen. However, the number of testes per segment may vary from 53 to 79. The testes are oval or nearly spherical varying in size from 39·1 × 30·0–69·0 × 46·0 μ.

The vasa efferentia join and give rise to two or three main ducts. These unite above Mehlis's gland to form the vas deferens. The first part of the vas deferens is dilated, forming an elongated vesicula seminalis which in mature segments is filled with sperms and measures 57·5-70·0 (57·5) × 18·4-27·6 (23·0) μ. From here the vas deferens proceeds anteriorly, dorsal or lateral to the uterine duct and above the ovary. As it passes forwards its course is somewhat sinuous and, at about the level of the atrium, it becomes highly convoluted. At this point it has a diameter of 11·5-13·8 (13·8) μ and is surrounded by a few relatively large and darkly staining cells. After forming about five major loops, one of which frequently lies antero-ventral to the cirrus pouch, it enters the cirrus pouch. Inside the pouch it is folded on itself about three times to form an ejaculatory duct. It then decreases in diameter to 9·2 μ giving rise to a straight unarmed thin-walled cirrus, 149·5-165·0 (149·5) μ long. The cirrus opens into the inner end of the common canal. Surrounding the ejaculatory duct and the cirrus, are numerous darkly staining gland cells.



Oochoristica nyctophili n.sp.

Fig. 16.—Medial section of a mature proglottis.
Fig. 17.—Horizontal section through part of an immature proglottis in the region of the genital atrium.
Fig. 18.—Horizontal section through part of a mature proglottis in the region of the genital atrium.

The cirrus pouch is transversely elongated, measuring 165·0-300·0 (240·0) × 30·0-53·0 (30·0) μ. It has thick muscular walls and in mature segments it extends in from the atrium for a distance of about 2/5 the width of the segment. It lies above the poral longitudinal nerve and either above or between the poral excretory vessels. From the aporal end of the pouch a few retractor muscles fan out and appear to join the transverse muscles of the proglottis.

Type Host: Nyctophilus geoffroyi Leach.

Type locality: Mt. Nelson, Hobart, Tasmania.

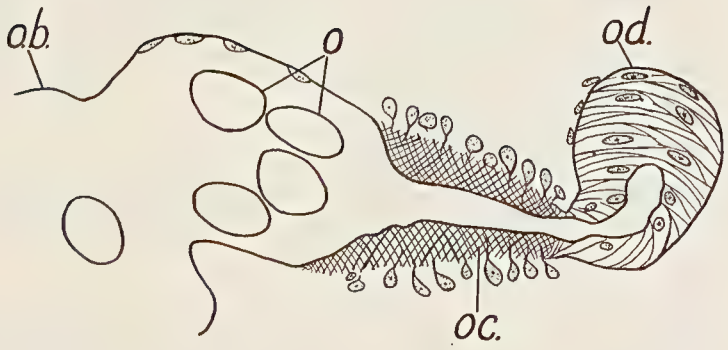
Type specimen: In Department of Zoology, University of Tasmania.

Affinities of *O. nyctophili* n. sp.

Hughes (1940) lists 17 species of *Oochoristica* from mammalian hosts. The following four species have since been recorded from mammals:—*O. procyonis* Chandler (1942) from *Procyon lotor; O. pennsylvanica* Chandler and Melvin (1951) from *Blarina brevicauda; O. wallacei* Chandler (1952) from *Spilogale interrupta* and *O. pedunculata* Chandler (1952) from *Mephitis* sp. (presumably *M. mephitis hudsonica*). In addition Baer (1949) redescribed *Taenia dipi* Parona (1900) and transferred it to the genus *Oochoristica*. Moreover Joyeux and Baer (1945) consider *O. ratti* Yamaguti and Miyata (1937) as a synonym of *O. symmetrica* (Baylis 1927) Meggitt and Subramanian (1927). In 1950 Self and McKnight recorded from *Mephitis varians* some cestodes which, in their opinion, were difficult to distinguish from either *O. mephitis* Skinker (1935) or *O. oklahomensis* Peery (1939). They placed their specimens in the species *O. mephitis* and extended the characters of this species so as to include those of *O. oklahomensis* which they then considered as a synonym of the former species. Finally, Choquette (1951) reported *O. mephitis* from *Mephitis mephitis* in Quebec.

The cestode described in the present paper brings the total species recorded from mammals to 23. Only one other species has so far been recorded from the Chiroptera, namely *O. taborensis* Loewen (1934) from *Lasiurus borealis borealis*.

O. nyctophili n. sp. may be readily distinguished from *O. taborensis* Loewen in that the testes do not occur anterior to the ovary, and the vitelline gland is not bilobed. Also the present species differs from all other species from mammalian hosts in two or more of the following characters: irregularly alternating genital pores; absence of a receptaculum seminis; testes not occurring in front of the ovary; the ovary distinctly bilobed; length of the strobila; width of the scolex; diameter of the suckers; and the size of the cirrus pouch. Furthermore, *O. nyctophili* n. sp. appears to be the only species from a mammalian host in which a sphincter muscle surrounding the poral end of the vagina, and a distinct oocapt have been recorded. In the form and arrangement of the female reproductive system, *O. nyctophili* n. sp. resembles *O. vacuolata* n. sp. However, the marked differences between the cestode from the bat, *Nyctophilus geoffroyi*, and other species of the genus, seem to warrant the establishment of the new species, *O. nyctophili*.



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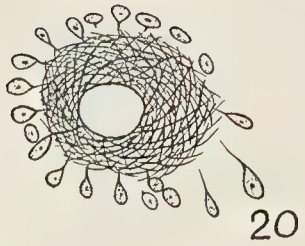

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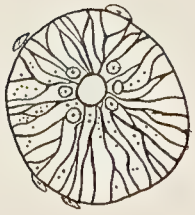

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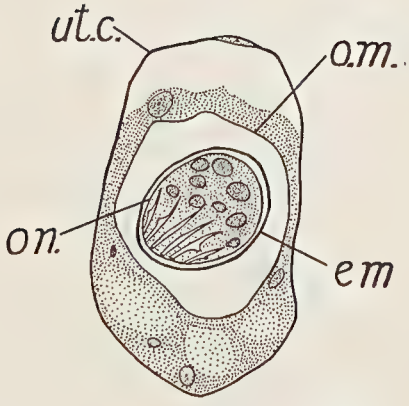

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Oochoristica nyctophili n.sp.

Fig. 19.—Vertical longitudinal section through the oocapt.
Fig. 20.—Transverse section through the oocapt.
Fig. 21.—Transverse section through oviduct beyond oocapt.
Fig. 22.—Uniovulate uterine capsule.

Infestation of Host

Only one specimen of *Nyctophilus geoffroyi* was examined and three mature cestodes were found in its small intestine.

Acknowledgments

The author expresses his appreciation to Dr. E. R. Guiler and Prof. V. V. Hickman for their interest and help. My thanks are also due to Mr. R. Wheeldon for collecting the specimen of *Nyctophilus geoffroyi* and to Mr. M. N. Maddock for the three specimens of *Egernia whitii* from Cooee.

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REFERENCES TO FIGURES

a.ut.—Anterior prolongation of uterus
c.—Cirrus
c.c.—Common canal
c.p.—Cirrus pouch
d.e.—Dorsal longitudinal excretory vessel
em.—Embryophore
f.d.—Fertilization canal
g.a.—Genital atrium
i.l.m.—Inner longitudinal muscles
M.g.—Mehlis's gland
n.—Lateral nerve
o.—Ova
o.b.—Ovarian bridge
oc.—Oocapt
od.—Oviduct
o.l.m.—Outer longitudinal muscles
o.m.—Outer membrane
on.—Onchosphere
ot.—Ootype
ov.—Ovary
p.a.ut.—Posterior aporal outgrowth of uterus
p.p.ut.—Posterior poral outgrowth of uterus
r.m.—Retractor muscles
r.s.—Receptaculum seminis
sp.—Sphincter
t.—Testes
ut.—Uterus
ut.c.—Uterine capsule
ut.d.—Uterine duct
vac.—Vacuoles of subcuticular cells
v.d.—Vas deferens
v.e.—Ventral longitudinal excretory vessel
vg.—Vagina
vt.g.—Vitelline gland

The intertidal zonation at two places in Southern Tasmania

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with 2 plates and 1 text figure

Summary

The zonation at two places in southern Tasmania is described. At South Cape Bay the belts on the shore are almost entirely dominated by the algae which is in contrast to the normal type of zonation in Tasmania. Some peculiar features of the distribution of several species are discussed, all of these peculiarities being attributed to wave action. At First Lookout Point, *Galeolaria* forms a belt on an exposed coast. This is attributed to peculiar intertidal conditions produced by offshore reefs.

(A) South Cape Bay

1. Introduction

South Cape Bay lies at the extreme south of Tasmania, latitude 43° 50′ South (Fig. 1) and is at the most southerly point of the Australian faunal region. The bay is wide but does not make a large indentation into the land mass. It consists of extensive rock platforms as well as surf beaches. Most of the area is backed by high cliffs but in several places there are steep grassy slopes which make access to the shore possible.

Fig. 1.—Outline map of southern Tasmania showing locality of the work described in the present paper.

The region is difficult to approach and to reach South Cape Bay it is necessary to travel from Hobart, camp overnight at Cockle Creek and the following day walk about six miles along poor bush tracks to the Bay. For this reason only two visits have been made to the area, each visit being of a few hours' duration.

The whole area is extremely exposed to wave action but there are certain important points of difference between the zonation seen here and that occurring on other exposed coasts of Tasmania. The basic zonation found on exposed coasts at Betsy Island, Eaglehawk Neck and the Freycinet Peninsula has been described in earlier papers (Guiler, 1951A, 1951B, 1952A). Comparisons of these areas are made in a later paper (Guiler, 1952B).

2. NOMENCLATURE

The regions of the shore are designated in accordance with the nomenclature of Stephenson and Stephenson (1949) while the meanings of the terms "zone" and "belt" are those proposed by Guiler (1953B).

3. ZONATION

Transect 1

Station: South Cape Bay.
Type: Exposed rocky coast.
Maximum wave action: 0 (1-10), 4, 9, 3.
Description: On the rock platform to the north-west of the boulder beach at the end of the track from Cockle Creek.
Geology: Sandstone with coal strata.
Tidal data: Nil.
Zonation: *Enteromorpha*

Enteromorpha with *Brachyodontes*
Centroceras with *Brachyodontes* and *Jania*
Lithophyllum with *Brachyodontes*
Lithophyllum with *Sarcophycus*
Sarcophycus and *Pyura*.

It has been noted (Guiler, 1952A) that at Eaglehawk Neck much of the wave platform is permanently under water due to waves filling almost imperceptible hollows on the surface of the platform. The same remark is equally true of South Cape Bay, where continual surf water flows over most of the platform.

THE SUPRALITTORAL ZONE

The Supralittoral zone is richly populated by lichens which are growing on the cliffs up to 30 feet above the level of the platforms. In the places where the grass slopes replace the cliffs the lichen belt is absent, tussock grass (*Poa* sp.) being the dominant plant. The coal beds are penetrated at many places by streams or water seepages and in these regions there are minute freshwater algae as well as liverworts and succulent plants growing in the Supralittoral. In the lower parts of the Supralittoral these freshwater seepages are often characterized by the presence of the bright green *Enteromorpha*. The area lies in a high rainfall belt and the influence of freshwater on intertidal life must be considerable.

THE SUPRALITTORAL FRINGE

On this transect there is no Supralittoral fringe such as is to be seen on other parts of the coast of Tasmania. Owing to the platform being largely a pond, especially in the upper region, the only place where the Supralittoral fringe indicator species (*Melaraphe unifasciata* (Gray))

occurs is on a raised part of the platform near the seaward edge. The seaweed *Enteromorpha* forms a belt on the shore at the bottom of the cliffs. There are no other species found associated with it to give a clue as to the tidal region in which it is found. This alga is usually regarded as forming a belt in the Supralittoral fringe but in this case there is some doubt as to the affinities of the species. There are no other species associated with it to give a clue as to the tidal region in which it is found. The height in relation to sea level at which the *Enteromorpha* is found does not provide any assistance since the alga is growing about two inches below the Midlittoral level. If the *Enteromorpha* is to be considered in the Supralittoral fringe then South Cape Bay is of considerable interest since the fringe occupies an area which, although at the furthest part of the shore from the sea, is actually at a lower tidal level than the rest of the shore. If the *Enteromorpha* belt is part of the Midlittoral the region is unique on account of there being no Supralittoral fringe. The *Enteromorpha* is constantly inundated by the surf which however does not, except in gales, cause any splash on the cliffs. This feature could result in a very sharp increase in the percentage air exposure with the result that the Supralittoral fringe is suppressed.

THE MIDLITTORAL

The rock platform is extensive and stretches out for 70 feet from the base of the cliffs, most of the platform falling into the Midlittoral zone (Plate 1). It is intersected by many channels, some of which are deep and contain algae characteristic of the Infralittoral.

Most of the upper part of the Midlittoral is nearly always kept wet by fresh water seepage and wave action. This area is shown by a discontinuous belt of *Ulva* and *Enteromorpha* running around the base of the cliffs and the grassy slopes. This belt is continuous with the pure *Enteromorpha* belt of the Supralittoral fringe.

There is evidence that the area covered by both the *Enteromorpha* belt and the mixed *Enteromorpha-Ulva* belt is subject to considerable seasonal variation. The extent of the variation in *Ulva* beds has been noted elsewhere (Guiler, 1954A) and seasonal variations in the density of *Enteromorpha* populations might also be expected. During the visit made in January, 1953, it was observed that both *Enteromorpha* and *Ulva* occupied considerably less area than in December, 1953. This is what might be expected, the heat of the summer sun in January having had considerable effect on the algae with a consequent reduction in the area covered by these seaweeds. In places where there is fresh water pouring out of the cliffs on to the platforms these algal beds are extensive, reaching out about 20 feet from the base of the cliffs. This is particularly accentuated in one area where a small waterfall pours over the cliffs and the wind-blown spray extends both the horizontal and vertical range of these algae.

On lower parts of the platform the *Enteromorpha* is joined by the mussel *Brachyodontes rostratus* (Dunker) to form a mixed belt. *Jania fastigiata* Harv. is the only other common species in this belt, and it forms mats in ponds at this level.

Most of the Midlittoral is dominated by *Centroceras clavulatum* (C.Ag.) Mont. associated with other species. This species has not been encountered in Tasmania before as a belt-forming species. In the upper part of the *Centroceras* belt *Brachyodontes rostratus* and *Melaraphe praetermissa* (May) are both very numerous and are subdominant to the alga. On lower parts of the shore *Jania fastigiata* joins this species along with *Lithothamnion lichenoides* (Ell. et Sol.) Foslie. This area is the first locality in which I have encountered the latter species and although the alga is very plentiful here, it is not found at First Lookout at Recherche Bay. It appears as if it is confined to the South-west area of the Tasmanian coast.

In the *Centroceras* belt there occur several species other than the above mentioned sub-dominants. The most common of these are the limpets, *Siphonaria diemenensis* (Quoy & Gaim.), *S. zonata* Ten.-Woods and *Patelloida marmorata* (Reeve). Of these three species, *S. diemenensis* is by far the most common. *Actinia tenebrosa* (Farq.), *Chthamalus antennatus, Lasaea australis* (Lam.), *Serpula* sp. and some tiny *Lithophyllum hyperellum* Foslie are numerous. A few *Melaraphe unifasciata* are also present. These species give a clear indication of the zone to which the belt can be assigned. It is certain that the *Centroceras* belt is Midlittoral because although a few *Melaraphe unifasciata,* the indicator species of the Supralittoral fringe, are found living in it, the greater number of species in the belt are never found in the Supralittoral fringe. Similarly, none of the species found are known to occur as indicators in the Infralittoral fringe.

It is when we try to decide the belt of the Midlittoral with which the *Centroceras* strip is homologous that there is some doubt. *Lithophyllum* is usually found in the lower Midlittoral or else in the Infralittoral fringe. The Patelloids and *Serpula* are usually very widespread in the lower Midlittoral while *Chthamalus* fits into the barnacle belt. The presence of a relatively dense algal covering on the shore probably assists the upward dispersion of a species requiring a high amount of immersion and it seems likely that in this case *Centroceras* can be considered as homologous to the barnacle belt of other Tasmanian coasts.

In this area a harder part of the rock has resisted denudation and projects about 1 foot above the general level of the surface of the platform. The area of this harder rock is small and the whole is thickly populated by *Melaraphe unifasciata.* The platform surrounding this elevation is in the *Centroceras-Brachyodontes* belt. Beyond this harder rock the belt dominated by *Centroceras* passes into a region dominated by the Patelloids, of which *Siphonaria zonata* is the dominant species. This condition is almost unique as *S. zonata* is usually much less numerous than *S. diemenensis.* Perhaps the nearest approach to this condition is seen on Betsy Island where *S. zonata* is locally dominant on sun sheltered rocks.

The Patelloid belt is interesting in this area not only because the dominant species is *S. zonata* but also because the large *Cellana* spp. are absent. The other Patelloids found in the belt are *S. diemenensis, Patelloida marmorata* and *P. conoidea* (Reeve). *Lithophyllum* also occurs in this belt as do *Actinia tenebrosa* and *Lichina lichenoides.* The latter species is particularly well developed.

Practically on the seaward edge of the wave platform there is a small elevation about one foot in height. I was surprised to see that this is populated by *Melaraphe unifasciata* with *Chamaesipho columna* on the seaward face of the prominence. The *Chamaesipho* belt grades into a *Lithophyllum* belt with *Brachyodontes*, Patelloids, a few *Galeolaria* tubes and, only rarely, *Catophragmus polymerus* Darwin.

The presence of *Melaraphe* in a position so close to the edge of the platform shows that the general surface level of the platform is at a level which is very close to the top of the Midlittoral zone. Consequently, the flora and fauna of the platform might be expected to be poor in species as well as in numbers. However, the continuous flow of surf water over the platform assists the population of the rock by a large number of individuals of a small number of species. This small number of species is greater than the number encountered at similar levels on other Tasmanian coasts.

THE INFRALITTORAL FRINGE

Below the *Lithophyllum* and *Brachyodontes* belt the platform falls away in a vertical cliff into very deep water. The face of the cliff is populated by Lithothamnion type algae mixed with *Pyura stolonifera* (Heller) (= *P. praeputialis* of earlier papers, vide Kott, 1953). These two species grade into a mixed belt populated by *Sarcophycus* and *Pyura*. It is impossible to examine this region of the shore in detail.

4. COMPARISON WITH OTHER ADJACENT AREAS AND DISCUSSION

Some of the most interesting zonations yet observed in Tasmania are to be seen on the platforms to the west of the above transect.

On a sloping shelf the mussel *Brachyodontes* forms a dense sheet, closely covering the rock. This condition is similar to that noted at Pirates Bay, except that the wave action at Pirates Bay is much less than that encountered at South Cape Bay. There are mussel beds formed by this species under similar conditions of wave action at Remarkable Cave at the South-Western end of Tasmania. At both South Cape Bay and Remarkable Cave these beds are restricted in area and it is difficult to see any physical factor or factors controlling the distribution of the beds. It may well be controlled by the chance incidence of successful spatfalls.

On one platform where the surf does not pass over the rocks, the zonation is basically the same as that noted above except that there are certain features which elaborate the picture. *Enteromorpha* which is found at the base of the cliffs has a few *Melaraphe unifasciata* living in it. The belt below this is a mixed *Melaraphe-Brachyodontes* which in turn is followed by a *Melaraphe-Brachyodontes-Chamaesipho* belt. This zonation may probably be interpreted as below:—

SUPRALITTORAL FRINGE: *Enteromorpha* with *Melaraphe*
MIDLITTORAL: *Melaraphe-Brachyodontes*
Melaraphe-Brachyodontes-Chamaesipho

The complete zonation on this platform is:—

Enteromorpha with *Melaraphe*
Melaraphe-Brachyodontes-Chamaesipho
Centroceras and *Brachyodontes* with *Scytosiphon*
Brachyodontes
Lithothamnion lichenoides with *Brachyodontes* and *Lichena*
Ulva with *Jania* and *Brachyodontes*
Xiphophora billardieri with *Pyura*
Xiphophora chondrophylla with *Pyura*
Sarcophycus with *Pyura* and *Lithothamnion* spp.

Both this section and the one described above as the type section are most interesting in that they show an almost pure algal zonation. In most other parts of Tasmania the belt-forming species are predominantly animals but at South Cape Bay and in the area of the Hormosiretum at Port Arthur (Cribb, 1954), algae have become the belt-forming species and the shore resembles the conditions seen in the cold temperate regions. The Hormosiretum at Port Arthur is very local and must be considered to be a special case but the algal zonation at South Cape Bay is so widespread that it merits separate consideration. It is obvious that different conditions operate in this area so as to permit two species not hitherto found forming belts on other parts of the Tasmanian coast to assume zonal significance. The presence of the two species of belt-forming seaweeds (*Lithothamnion lichenoides* and *Centroceras clavulatum*), an alteration in the ecological status of *Catophragmus* (see below) and the presence of both *Xiphophora chondrophylla* and *X. billardieri* as belt-forming species above the *Sarcophycus* belt, all point to a major re-orientation of belts on the shore. The principal feature of the new zonation which becomes apparent is the dominance of the algae on the shore. This is a feature of cold temperate regions which has not yet been recorded in Australian seas. It seems probable that South Cape Bay lies on the fringe of a geographical province which is different from the other provinces of Australia. The province is represented by only the restricted area of Southern Tasmania on account of the absence of land masses suitable for intertidal life. It seems unlikely that this province is the northern most limit of the Sub-Antarctic Region since the alga *Sarcophycus* would be replaced by *Durvillea antarctica* (Cham.) Hariot if that were the case. The more acceptable hypothesis is that this is a small, hitherto undetected, province of the Australian Region. However, much collecting and taxonomic work will need to be carried out before this hypothesis can be confirmed or otherwise.

Table 1 shows the distribution of the principal intertidal species in Tasmania. With greater collecting it will be possible to fill in many of the gaps and to add other species to this basic list. Comparison of this list with that given by Bennett & Pope (1953) supports the conclusions reached by these authors that Tasmania is a cool temperate region with close affinities to a southern Victorian region.

TABLE 1

Distribution of the important intertidal species in Tasmania

	North Coast	South Coast	East Coast	West Coast
PORIFERA				
Tethya diploderma Schmidt		X	X	X
Hymeniacidon perlevis (Montagu)		X	X	
Grantessa hirsuta (Carter)		X		
COELENTERATA—Hydroidea				
Obelia australis v. Lind.		X	X	
geniculata (L.)		X		
Gonothyrea hyalina Hincks		X		
Silicularia campanularia (v. Lend.)		X		
Orthopyxis caliculata (Hincks)			X	
Plumularia setacioides Bale		X	X	
setacea (Ellis)			X	
Aglaophenia plumosa Bale		X	X	
parvula Bale		X		
Actiniaria				
Oulactis muscosa (Drayton)	X	X	X	X
Actinia tenebrosa (Farq.)	X	X	X	X
Anthothoe albocincta (Hutton)	X	X	X	X
Anthopleura aureoradiata (Stuck.)		X		
Phlyctenanthus australis Carlgren		X	X	X
Phlyctenactis tuberculosa (Quoy & Gaim.)		X	X	X
CTENOPHORA				
Physalia australis	X	X	X	X
TURBELLARIA				
Leptoplana australis Laidlaw	X	X	X	
ANNELIDA				
Galeolaria caespitosa Lam.	X	X	X	X
CRUSTACEA				
Cirripedia				
Ibla quadrivalvis Cuvier		X	X	
Balanus trigonus Darwin		X		
Tetraclita purpurascens (Wood)	X	X	X	X
Elminius modestus Darwin	X	X	X	
simplex Darwin	X	X	X	
Chthamalus antennatus Darwin	X	X	X	X
Chamaesipho columna (Spengler)	X	X	X	X
Catophragmus polymerus Darwin	X	X	X	X
Isopoda				
Paridotea munda Hale		X		
Euidotea peronii (M.-Edw.)	X	X	X	
Ligia australiensis Dana	X	X	X	X
Cymodoce gaimardii M.-Edw.		X		
Amphoroidea elegans Baker			X	
tridentata (M.-Edw.)	X			
trispinosa (Haswell)	X	X	X	
Zuzara venosa (Stebbing)	X	X		
Sphaeroma quoyana M.-Edw.		X		
Amphipoda				
Orchestia marmorata Haswell	X		X	
Talorchestia diemenensis Haswell		X	X	
quadrimana (Dana)		X		

	North Coast	South Coast	East Coast	West Coast
Decapoda				
Palaemon serenus (Heller)	X			
Macrobrachium intermedius (Stimpson)		X	X	X
Petrolisthes elongatus M.-Edw.	X	X	X	X
Petrocheles australiensis Miers		X		
Callianassa ceramica Fulton & Grant	X	X	X	
Upogebia simsoni (Thomson)		X	X	
Lomis hirta (Lam.)	X	X	X	X
Leptochela robusta Stimpson	X			
Petalomera lateralis (Gray)		X	X	
Cancer novae-zealandiae (Jacq. & Lucas)		X	X	
Halicarcinus planatus (Fabr.)	X			
ovatus (Stimpson)		X	X	
Leptomithrax sternocostulatus (M.-Edw.)	X	X		
Paramithrax minor Filhol		X	X	
Naxia aurita (Latr.)		X		
Nectocarcinus tuberculosus M.-Edw.		X	X	X
integrifrons (Latr.)		X		
Ovalipes bipustulatus M.-Edw.		X	X	X
Heteropilumnus fimbriatus (M.-Edw.)		X		
Pilumnus tomentosus Latr.	X		X	
Leptograpsus variegatus (Fabr.)	X	X		
Brachynotus octodentatus (M.-Edw.)	X			
spinosus (M.-Edw.)		X		X
Cyclograpsus punctatus (M.-Edw.)	X	X	X	X
Paragrapsus quadridentatus (M.-Edw.)	X	X	X	X
gaimardii (M.-Edw.)	X	X	X	X
Plagusia capensis de Haan	X	X	X	X
Helice haswellianus (Whitelegge)		X	X	
Heloecius cordiformis (M.-Edw.)		X	X	
Mictyris platycheles (M.-Edw.)	X	X	X	
Ebalia laevis (Bell)	X	X		
MOLLUSCA				
Amphineura				
Poneroplax albida (Blainville)		X	X	X
costata (Blainville)		X	X	
Ischnochiton lineolatus Blainville	X	X	X	
milligani Iredale & May	X	X	X	
mayi Pilsbry		X	X	
Ischnoradsia evanida Sowerby		X	X	
Haploplax smaragdina (Angas)	X	X	X	X
Sypharochiton pellis-serpentis (Quoy & Gaim.)	X	X	X	X
Gastropoda				
Scutus antipodes Mont.		X	X	
Hemitoma aspera Gould		X		
Haliotis noevosum Martyn		X	X	X
Austrocochlea concamerata (Wood)	X	X	X	
constricta (Lam.)	X	X	X	X
obtusa (Dillw.)	X	X	X	
odontis		X	X	
Clanculus plebejus (Philippi)		X	X	
Fossarina petterdi Crosse		X	X	
Astele subcarinata Swainson		X	X	
Phasianella australis (Gmelin)		X	X	
Subninella undulata (Solander)	X	X	X	X
Melanerita melanotragus (Smith)	X		X	X
Patelloida alticostatus (Angas)	X	X	X	X
marmorata (Ten. Woods)		X	X	X
Montfortula conoidea (Reeve)	X	X	X	X
Actinoleuca calamus (Grosse & Fischer)		X	X	

	North Coast	South Coast	East Coast	West Coast
Notacmaea septiformis (Quoy & Gaim.)		X	X	
Cellana limbata (Philippi)		X	X	X
variegata (Blainville)		X	X	
Melaraphe praetermissa (May)		X	X	X
unifasciata (Gray)	X	X	X	X
Bembicium melanostoma (Gmelin)		X	X	X
nanum (Lam.)	X	X	X	
Patella perplexa (Pilsbry)	X			
Dardanula melanochroma (Tate)	X	X		
Merelina australiae (Ten.-Woods)		X		
Assimania brazieri (Ten. Woods)		X		
Pyrazus diemenensis (Quoy & Gaim.)		X	X	
Argobuccinum tumidum (Dunker)	X	X	X	
Polinices conicus (Lam.)	X	X	X	X
Trivia australis (Lam.)		X	X	
Marginella pygmaea Sowerby		X	X	
Floraconus anemone (Lam.)		X	X	
Fasciolaria australasia (Berry)	X	X	X	X
Colus novae-hollandiae (Reeve)		X	X	
Parcanassa pauperata (Lam.)		X	X	X
Cominella eburnea (Reeve)		X	X	
lineolata (Lam.)	X	X	X	X
Salinator fragilis (Lam.)	X	X		
Siphonaria diemenensis Quoy & Gaim.	X	X	X	X
zonata Ten.-Woods		X	X	X
tasmaniensis Ten.-Woods		X	X	
Philine angasi (Crosse & Fischer)		X	X	
Tethys tasmanica Ten.-Woods		X		
Lamellibranchiata				
Glycymeris striatularis (Lam.)	X	X	X	X
Neotrigonia margaritacea (Lam.)		X	X	
Mytilus planulatus (Lam.)	X	X	X	X
Brachyodontes erosus (Lam.)		X	X	
rostratus (Dunker)	X	X	X	X
Lasaea australis (Lam.)	X	X	X	X
Clausinella placida (Philippi)		X	X	
Bassina disjecta (Perry)	X	X	X	X
Marcia corrugata (Lam.)		X	X	
scalarina (Lam.)		X	X	
Soletellina biradiata Wood		X		
Mactra rufescens Lam.		X	X	
Spisula trigonella Lam.		X	X	
Anapella cycladea (Lam.)		X	X	
Amphidesma angustata (Reeve)	X	X	X	
Hiatella australis (Lam.)		X	X	
ECHINODERMATA				
Asteroidea				
Asterina scobinata Livingstone	X	X	X	
Astropecten schayeri Döderlein		X		
Coscinasterias calamaria (Gray)		X	X	X
Patiriella calcar (Lam.)	X	X	X	X
exigua (Lam.)		X	X	X
gunnii (Gray.)		X	X	
Tosia australis Gray	X	X	X	
Crinoidea				
Crinoid sp.		X		
Ophiuroidea				
Amphiura constricta Lyman		X	X	
Ophionereis schayeri (Müller & Troschel)		X		

	North Coast	South Coast	East Coast	West Coast
Holothuroidea				
Chiridota gigas Dendy	X	X	X	
Mensameria thomsoni (Hutton)		X	X	
Paracaudina australis (Semper)	X	X		
Stichopus mollis (Hutton)		X	X	
Echinoidea				
Amblypneustes ovum (Lam.)		X	X	X
Echinocardium cordatum (Pennant)		X	X	
Heliocidaris erithrogrammus (Val.)		X	X	X
UROCHORDATA				
Ciona intestinalis L.		X		
Pyura stolonifera (Heller)		X	X	X
Boltenia pachydermatina Herdman		X	X	X

The second of these sections is one of the most interesting, yet perplexing, in Tasmania; a Coralline belt is usually found on the lower part of the shore, somewhere near the Patelloid belt. However, in this instance, the various Coralline seaweeds are found at a remarkably high level on the shore. It is possible that the spray-laden atmosphere and the prevalent rough weather have enabled the algae to grow higher on the shore in this area than on other parts of the coastline.

The presence of *Xiphophora chondrophylla* and *X. billardieri* is noteworthy. Up to date this alga has been regarded as an indicator of the intensity of wave action, being found in places where the wave action is somewhat reduced below the maximum, *Sarcophycus* being the indicator of the most intense wave action, followed by *Lessonia* and then *Xiphophora* spp. At Fossil Island it was noted that the presence of large boulders reduced the wave action so that a vertical zonation of algae resulted, those species with the least wave action toleration being found highest on the shore. In other words a horizontal zonation was re-orientated into the vertical plane. The same alteration has taken place at South Cape Bay although *Lessonia,* the species intermediate between *Sarcophycus* and *Xiphophora* is represented by only a few plants. In this instance the reason for the re-orientation of the zones is not clear. The wave action may be slightly less higher on the shore in the *Xiphophora* belt than it is in the *Sarcophycus* belt but this reduced wave action is still much more intense than any other wave action which I have seen tolerated by *Xiphophora.*

The presence of *Pyura* in the *Xiphophora* as well as in the *Sarcophycus* belt indicates that the former weed is occurring in the Infralittoral fringe. At this particular point the vertical height between the crest of the waves and the troughs is of the order of 12 feet. In gales this distance must be much greater. Yet all of this area is exposed intermittently and forms a very extensive Infralittoral fringe. This fringe is homologous with the narrow band about 6 inches in vertical height seen on sheltered shores.

The distribution of the large limpet, *Cellana limbata* (Philippi) is yet another interesting feature of the area. The limpet is absent from the first two platforms examined but on another similar platform the

species is numerous with individuals reaching a large size. The limpet appears to thrive in places where the wave action is just below the maximum. This is not in accordance with the observed distribution of the species on the East Coast where *Cellana* usually inhabits some of the most exposed places.

The surf barnacle, *Catophragmus polymerus* Darwin, follows a similar distribution pattern. On the East Coast and at Betsy Island this barnacle is found in places where the wave action is not only intense but where there is also broken water. However, the species is also found in regions where there is less wave action but considerable surf, e.g., at Frying Pan Island in Port Arthur. At South Cape Bay the barnacles are almost totally absent from fully exposed places, nor are they found on the surface of the platform. Clefts and narrow channels in the platforms are richly populated by this species, some of the largest specimens measuring 5 cm. from the base to the terga, these specimens being the largest I have seen in Tasmania. It is important to note that the distribution of *Catophragmus* on the South Coast forces an alteration to a previous conclusion regarding the relation of the belts formed by this species in Tasmania and Australia. In the earlier paper (Guiler, 1954B) it was pointed out that *Catophragmus,* although forming intertidal belts in Tasmania, does not form them under exactly the same ecological conditions as in New South Wales. This conclusion must now be extended so that it is clear that there is no *Catophragmus* belt in southern Tasmania.

5. OTHER SPECIES

The whole area is rich in species, most of which occur in ponds or in Infralittoral clefts. The area would undoubtedly furnish interesting Infralittoral collecting were it not for the difficulty of access and removal of material. However, the intertidal region is not rich in species probably due to the intense wave action killing or removing all but the most robust and hard-clinging species. A list including most of the other species inhabiting the various zones is given below.

Supralittoral Fringe:

Enteromorpha sp.
Melaraphe unifasciata (Gray)
Melaraphe praetermissa (May)
Ulva lactuca L.

Midlittoral:

Melaraphe unifasciata
Brachyodontes rostratus
Chamaesipho columna
Siphonaria diemenensis
Siphonaria zonata
Catophragmus polymerus
Cellana limbata
Patelloida conoidea
Patelloida marmorata
Galeolaria caespitosa (scarce)
Brown anemone

Algae

Centroceras clavulatum (C.Ag) Mon.
Jania fastigiata
Jania spp.
Lithophyllum hyperellum Foslie
Lichena officinalis
Ulva lactuca
Porphyra sp.
Lithothamnion (flesh coloured)
Lithothamnion (red coloured)
Adenocystis lessonii

Midlittoral: *continued.*

Dicathais baileyana (Ten. Woods)
Patiriella calcar (Lam.)
Patiriella exigua (Lam.)
Oulactis muscosa (André)
Sypharochiton pellis-serpentis (Quoy & Gaim.)
Poneroplax albida (Blainville)
Calliostoma hedleyi Pritchard & Gatliff
Actinia tenebrosa
Subninella undulatus
Lepidonotus sp.
Serpula sp.
Lasaea australis (Lam.)

Algae: *continued.*

Scytosiphon lomentarius
Colpomenia sinuosa
Lithothamnion lichenoides

Infralittoral fringe:

Pyura stolonifera

Xiphophora chondrophylla
Xiphophora billardieri
Lessonia corrugata
Lithothamnion spp.

(B) FIRST LOOKOUT POINT

This point which is composed of broken reefs, is much easier of access than South Cape Bay, being only two miles from Cockle Creek. The wave exposure here is almost as great as that at South Cape Bay, the area being exposed to southerly gales. It is, however, sheltered from the prevailing south-westerly weather.

The most important feature of the zonation is the presence of an extremely well-developed *Galeolaria* belt co-existing on exposed shores with *Sarcophycus.* I have always pointed out that the presence of *Galeolaria* colonies on exposed coasts is feature of the coasts of New South Wales which is not found in Tasmania. In the area under consideration, the zonation is as set out below.

Melaraphe
Chamaesipho
Chamaesipho and *Siphonaria zonata*
Galeolaria and *Lithophyllum*
?Patelloids
Sarcophycus

An unusual feature is the large quantity of *Lithophyllum* associated with the serpulids.

The salient physical factor is the amount of surf breaking on the reefs. The reef habitat appears eminently suitable for colonization by *Catophragmus* yet the barnacle is absent, careful searching failing to reveal a single specimen. The species appears further down the coast to the South at a place where there is no *Galeolaria belt.* It would appear, therefore, that the serpulids have replaced *Catophragmus* in this very restricted part of Tasmanian shores and so reproduced Australian condi-

tions. The reason for this behaviour probably lies in the submarine reefs which lie offshore at this point. These reefs are often awash at low water and they form an effective backwater which, although providing plenty of surf, prevent the full force of the waves crashing on the shore. Dakin, Bennett & Pope (1948) record that *Galeolaria* is a surf-loving species found at exposed places in New South Wales, so that it is possible that conditions suitable to this species are reproduced at this point. Offshore reefs of this nature are not common in Tasmania which would explain the absence of this type of zonation from anywhere else on the coastline.

In a recent paper, I pointed out that there was a series of cyclical changes constantly taking place on the coasts of Tasmania (Guiler, 1953A). On a sheltered coast this cycle reaches its climax in thick *Galeolaria* beds. It is possible that this is true of all other types of coast and First Lookout Point is the only place in Tasmania that is in its climax state. I believe this to be most unlikely since *Galeolaria* is absent or scarce on all other exposed places. The more likely explanation is that offered above where unusual conditions occur for the growth of *Galeolaria*. It is highly significant that at distance of 800 yards either side of First Lookout Point the zonation is normal, though with *Lithophyllum* replacing *Catophragmus*.

Catophragmus polymerus presents several problems in its distribution. On the East Coast this species is found in the most exposed places and at Betsy Island the barnacles also thrive in exposed, rough water. However, at both First Lookout Point and South Cape Bay the species is rare in exposed places, in no places forming a belt. It is found in sheltered clefts and some " cryptic " places. On the west coast at Trial Harbour the species is plentiful in its normal habitat. It is probable that at this latitude, *Catophragmus* is just on the southern limit of its geographical range and is seeking a less rigorous habitat. A similar feature has been noted with another Australian barnacle, *Tetraclita purpurascens* Wood, which is entirely semi-cryptic in Tasmania. This species is rare in the South.

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FIG. 1.—*Sarcophycus* on the rocks to the north of the transect, Dec. 1953. The intensity of the spray can be judged from the haze in the background. Printed from a Kodachrome.

FIG. 2.—The platforms at South Cape Bay, Dec. 1953. The prominent dark patches are *Brachyodontes*, the lighter areas are *Centroceras* and some of the white patches are *Jania* or *Lithothamnion*.

Pirates at Recherche Bay

or

The Loss of the Brig. "Cyprus"

By

E. R. Pretyman

(Read 4th August, 1953)

Monday next the tenth of August is the one hundredth anniversary of the day on which public demonstrations of all kinds were held to celebrate the official end of Transportation to Tasmania; and no doubt many of us have heard stories and accounts of the efforts made by our forbears to clear this Island of the evils of the System and to rid it of its Penal Settlements.

The brig *Cyprus* was closely associated with the work of Transportation; indirectly the cause of Macquarie Harbour Penal Settlement being closed; and the story of her capture, one means perhaps by which public thought in England was slowly aroused to the realization of the wrongs done men and women sentenced to the punishment of Transportation.

The most exciting incident in this little vessel's career took place in the year 1829 as she was on her way from Hobart Town to Macquarie Harbour, with convicts and supplies for the penal settlement there; but before giving the details, some reference should first be made to Recherche Bay, to the discovery of Macquarie Harbour, the formation of its penal settlement and to the conditions under which convicts suffered about the time the *Cyprus* sailed out of Hobart Town on what was to be her last voyage from this port.

Recherche Bay on the southern coast of Tasmania was discovered by accident in the year 1792. It is recorded that Admiral Bruny D'Entrecasteaux with two ships under his command, left France in September, 1791; reached the Cape of Good Hope early in 1792 and from thence set his course for Van Diemen's Land.

Soon after reaching Australian waters the two vessels ran into a severe storm. A wave unexpectedly broke against the Commander's ship. The violence of the movement caused D'Entrecasteaux to fall against the corner of a barrel organ being brought out as a possible gift to some savage chief. At first it was thought he had fractured a rib and we are told that the pain he suffered was so great that whenever he sneezed it threw him into a fainting fit. He was not permitted to leave his cabin and was therefore dependent on others for taking observations.

After passing the Mewstone Rock on 21st April, the lieutenant responsible for such reports gave the bearing of Eddystone Rock as South West instead of so many degrees South *East* of their position. Their course was altered and instead of sailing well into Storm Bay they reached the area at the southern entrance to Storm Bay Passage. Towards evening

two boats were lowered to search for suitable anchorage. Next morning both ships began a long tow to the selected harbour which was not reached until 25th April.

The Frenchmen highly delighted with the surroundings, called the inlet where they lay " Port D'Entrecasteaux " and decided to make it headquarters for local exploring expeditions. The Bay itself was carefully surveyed, marked in on their charts and named " Baie de la Recherche " (after the vessel which D'Entrecasteaux commanded). " D'Entrecasteaux Channel " was discovered, named and surveyed by an expedition from Recherche Bay and in the process a small island off the south west of Bruny Island visited and named by the crew Partridge Island.

After Tasmania was settled Recherche Bay became a kind of half-way-house for vessels sailing up the West Coast and was a popular anchorage for boats engaged in whaling.

Macquarie Harbour on the west coast of Tasmania was discovered by James Kelly.

In the Library of the Royal Society is an account, in Kelly's own handwriting, of a voyage he made in a whale boat with the idea of examining in detail the then largely unknown coast of Van Diemen's Land. They set out from Hobart Town on 12th December, 1815, spent a night at Recherche Bay and four days later entered Port Davey. Here they caught wild fowl, black swans, teal, eels and fish which they took with them for food on the next stage of their journey.

From 22nd to 26th December they were weather bound in a snug Cove near High Rocky Point.

On 28th December, Kelly wrote, " Weather calm, pulled along shore to northward—at noon rounded a projecting point which opened into an inlet—we found a strong current running out which make us believe there must be a large river in the south east direction.".

At that time the whole face of the coast was on fire, he tells us, and the smoke so thick that they could not see one hundred yards ahead of the boat. They rowed against the current into the passage between a small island and what appeared to be the mainland. Later the same afternoon the smoke cleared a little Kelly and his party found themselves on a large sheet of water, near a small island on which they landed to spend the night. So, under the cover of a pall of smoke and haze, James Kelly and his brave little crew, discovered and entered the only worthwhile harbour on the west coast of Van Diemen's Land.

Next morning, 29th December, something of the extent of the enclosed water could be seen and in honour of the Governor of New South Wales—Lachlan Macquarie—they called it Macquarie Harbour, the name it retains to the present day. For three days they sailed and rowed about this almost landlocked sea naming various features after well-known people.

Early on 1st January, 1816, Kelly and his men set out from Macquarie Harbour well pleased with their discoveries and ready to continue their voyage—eventually to go, in some forty-nine days—almost completely around our Island.

Approximately three years later Lieutenant Governor Sorell, finding it difficult to house and control the large number of convicts then being sent to Van Diemen's Land, conceived the idea of sending the worst and most hardened prisoners to some remote spot on the coast, and so sent for James Kelly. Kelly, by this time had made a number of trips to Macquarie Harbour for Huon Pine and other timbers and having circumnavigated the whole Island, could speak with personal knowledge. Macquarie Harbour was the " remote spot " he suggested.

After confirmatory surveys, two brigs, the " Duke of York " and " Prince Leopold " were fitted out to take the unhappy convicts to the new and isolated prison on the West Coast. The " Duke of York " with the commandant of the projected settlement—Lieutenant Cuthbertson—reached Macquarie Harbour on 2nd January, 1822.

The thickly timbered Sarah's Island (named by Kelly after the wife of Thomas William Birch) was chosen as the site for headquarters. The women convicts—for there were women sent round with the early parties—were placed on Grummet Island—three quarters of a mile away from Sarah's Island.

Most of the men were sent almost immediately, under strict supervision, to cut timber on the mainland. Many attempts to escape were made and the hardships these men underwent in their efforts to gain freedom can hardly be credited.

On 22nd December, 1823, the first Commandant—Lieutenant Cuthbertson—lost his life as he was returning from an attempt, in a severe storm, to save the first little vessel built at the settlement from shipwreck.

Lieutenant Wright was then appointed and under his direction a farm was commenced on the mainland. It was from this farm that a party of prisoners managed to evade their guard and escape in a small boat. Later, under the leadership of Matthew Brady, they and others became the terror of all settlers living in isolated districts of Tasmania.

Before these convicts made their get-a-way, they captured Doctor Garrett, the settlement's medical officer and determined to give him a taste of the punishment they themselves had at times received. In spite of the doctor's expostulations, he was ordered to strip for the application of the cat-o'-nine tails. He had just managed slowly and deliberately to remove his coat when young Brady put in an appearance and would not allow him to be touched. In this way Brady showed his appreciation for kindly treatment given him by the doctor when he was in hospital. It is not hard to imagine the doctor's delight at being released so unexpectedly.

Besides endeavouring to escape some poor wretches committed murder well knowing that they would be sent to Hobart Town for trial and sentence. It was soon realized that these convicts had no other object in mind, than that of obtaining a change of surroundings.

After Lieutenant Wright, Lieutenant Butler was appointed to administer the affairs of the Penal Settlement and it is recorded that under his supervision almost a daily improvement could be seen in every branch of Government service there. His firm, severe and yet just and humane treatment had its effect. Building after building was erected, excellent quays were made to border the front of Sarah's Island and fences of successive tiers of palings some thirty feet high, were raised to protect the rear of the settlement from the blasting effects of the north west winds, raft after raft of Huon pine came from the Gordon River and boats, cutters, schooners and brigs left the dockyard.

Along the waterfront were erected the stores, the workshops, shoemakers' quarters and behind them stood the penitentiary. Further back were erected the offices, superintendent's quarters, the master of shipbuilders' premises, the bakehouse tannery and gaol. To the right of these stood the residences of the engineer, the surgeon, the commandant and the chaplain. Here and there sawpits were dug in convenient places. The remaining unoccupied areas of the island were developed into gardens which eventually produced, it is said, as fine vegetables as could be grown anywhere. These were not for the convicts however, except perhaps when they were in hospital, or on other rare occasions.

They, the prisoners, after a breakfast of " skilly ", a thin porridge made of flour or oatmeal, water and salt, were sent off to allotted jobs, to the mainland to cut timber and to other arduous tasks. They received no other food until the end of the day when on their return they were given a good meal of salt meat and vegetables (mostly potatoes) allowed to dry as far as possible their usually sodden clothes and then sent to their comfortless resting places for the night. The whole set up of this penal station was to make men FEEL their punishment.

Colonel George Arthur, who followed Colonel Sorell as Lieutenant Governor, saw the value of the Penal Settlement at Macquarie Harbour and continued to make transportation to it something to be greatly feared, in consequence there were numerous attempts made by prisoners to escape from the vessels taking them to that desolate and dreaded spot.

Until 1825 the brig " Duke of York " was usually used in this service but an examination then disclosed that she was completely unseaworthy. Shipping suitable for the West Coast and for sailing over the bar into Macquarie Harbour was very limited. Colonel Arthur made immediate application to Sir Thomas Brisbane, Governor in Chief at Sydney for a new vessel. One, almost completed, lay near Sydney and this Sir Thomas promised would be appropriated to service in Van Diemen's Land; but in March 1826 Colonel Arthur received notification that the new vessel could not be spared and he would have to make other arrangements.

Following a survey of local vessels, Captain John Briggs, on 6th June, 1826, offered a brig called the " Cyprus " for the USE of His Majesty's Government; but as Governor Arthur wished to *purchase* a vessel, he was asked to state the price at which he would sell. Then because he included a grant of land in his terms, Briggs was asked to quote again. This time he said Seventeen hundred pounds in British sterling money.

With due Government caution a Committee was appointed to inspect and report on the vessel. Two months later the " Cyprus " became Government property.

This sturdy little vessel then for three years sailed back and forth to Macquarie Harbour, mostly from Hobart Town but sometimes from Port Dalrymple or Launceston. To Macquarie Harbour she took supplies and usually a complement of convicts. From Macquarie Harbour she brought Huon pine and other timbers, furniture and articles manufactured by convicts for the Government. Once she took the Rev. Wm. Schofield, Wesleyan Methodist Missionary and first chaplain at Macquarie Harbour, to a four year term of duty at this West Coast station. She proved to be a very seaworthy and reliable little vessel and was of considerable value to the Government.

Suddenly, in August, 1829, this hardy little vessel received all the publicity any owners could have wished for. The news flew round Hobart Town that she had been piratically seized by convicts being transported to Macquarie Harbour. There was much speculation as to how such a thing could happen and many theories were advanced before the details became available.

The sequence of events ran something like this:—On 6th August the " Cyprus " left Hobart Town on one of her usual trips with supplies for Macquarie Harbour. All told she had some 62 souls on board. Included were thirty-one convicts, a pretty bad lot all in double irons, under a guard from the 63rd Regiment in charge of Lieutenant Carew. Lieutenant Carew had with him his wife and two children and with them went all their worldly possessions, because of his transfer.

About a fortnight later the ship " Orelia " left Hobart Town making her way to sea via D'Entrecasteaux Channel. As she neared Partridge Island off the south western end of Bruny Island, Mr. Lovett, pilot of Hobart Town, who was taking her down, saw through the gathering gloom of evening an unusual light flickering from the island. Investigation appeared to be necessary, the ship was brought to and he was rowed ashore. Here to his surprise he found two men, both convict sailors who claimed they had just come from Recherche Bay in a kind of coracle to obtain assistance for a stranded party of forty odd persons from the brig " Cyprus ". They explained that the position of those people was desperate and unless something could be done quickly the marooned people would die of starvation.

To add strength to their story the men produced Two Scraps of Paper, one of which was addressed " P. Munro Esq.," headed " Researche Bay, August 23rd, 12 p.m." and its message read, " These will inform you that the brig ' Cyprus ' has been captured by prisoners who sent us

together with family, soldiers and sailors etc., in all 40 persons, on shore. We have been here (Research Bay) nine days and are without provisions, your immediate assistance will be the cause of saving us from starvation. The men who bear this have behaved themselves in an exemplary manner and of course will be treated accordingly." A postscript read " Four of the guards severely wounded ".

On the second scrap of paper, much smaller than the first and addressed to John Burnett, Colonial Secretary, was written " We fail for want of paper, you therefore will apprise His Excellency in the Lieutenant's name of our misfortune ". On the other side was written, " You will not destroy the boat as it was made with three pocket knives. Eighteen prisoners gone in the brig, five making Hobart thro' the bush ".

Quite recently I discovered these two interesting pieces of paper roughly folded and pinned to the written evidence of the event and still held among Government records preserved in the State Archives. Their discovery was the reason for my preparing this paper.

Pilot Lovett must have been amazed at what he read and at what he saw of the crazy craft in which these two brave men had risked their lives in order to obtain assistance.

Immediate instructions were given his boat's crew to make for Birch's Bay with the information for Mr. Munroe. Munroe was superintendent at the convict sawmilling station there, and in his turn under the date 26th August, 1829, he wrote to the Lieutenant Governor, " I loose no time in forwarding a person to town with the intelligence that I proceed immediately in a whale boat with provisions for the distressed persons in Research Bay, I also despatched the ' Opossum ' sloop, which happened to be here, which together with the boat will be able to bring the whole party up.".

Munroe's letter was sent, again in the pilot's boat, to Hobart Town arriving there in the early hours of the following morning. The matter was considered to be so urgent that the message was delivered to the Lieutenant Governor, according to the " Colonial Times " " long before His Excellency's usual time of rising ". Colonel Arthur sent at once for Lieutenant Hill, the Port Officer, and gave him orders to despatch the " Opossum " to the rescue without a moment's delay. This action had, of course, been anticipated by Mr. Munroe as his note indicates.

Hobart Town's waterfront must have been all agog, but there was nothing to do but await events.

It appears that after leaving Hobart Town on 6th August, the " Cyprus " sailed for Recherche Bay. On her arrival there the wind was from the wrong quarter for proceeding up the West Coast, so her Captain while waiting for an expected change, decided to try and recover two anchors lost in a gale, on a previous trip. Then the wind dropped altogether and they lay in a dead calm.

Because fresh fish were always a welcome addition to the usual ship board fare, Lieutenant Carew, the doctor and a couple of men, one of them a convict sailor by the name of John Popjoy, took the brig's smaller boat and rowed to a spot some 250 yards away.

At the time this party left the brig, everything was quiet on board. Five convicts were on deck, " taking the air ", a privilege often given prisoners because of the cramped quarters they occupied, and three soldiers kept guard. All others aboard the vessel were below having their evening meal.

Suddenly there was a scuffle aboard the " Cyprus ". The convicts on deck had attacked the sentries, knocking them down and seizing their arms. At the same time a hencoop was flung across the soldiers' hatchway, thus barring help from those below. Other prisoners scrambled from their quarters and were soon releasing one another from their irons. The Captain, hearing the struggle from the cabin rushed on deck, to be promptly knocked senseless. A shot was fired by one of the soldiers below, but all it did was to fill their quarters with powder fumes and to attract the attention of the fishing party, and they, sensing immediately that something was wrong aboard the brig, began to row hurriedly back to the vessel.

By this time it was practically dark and Lieutenant Carew and his fishing party coming alongside were ordered to stand off. The lieutenant commenced to point out the folly of the convicts' action and even offered to say nothing about the affair if they would return the vessel but his efforts had no effect.

Those aboard the " Cyprus " were then taken and landed at five different places. Very little food was allowed them and they were given nothing for shelter. Of the twenty remaining on board, two were sailors held under compulsion, because it was hoped they would join the pirates and later help work the brig.

A convict sailor, William Swallow, but also known by many other names was elected the Cyprus's new Master, another man named Ferguson was made lieutenant and immediately rigged himself out in Lieutenant Carew's best uniform, sword and all, while a third named Jones became the Mate. Others discovered the rum aboard and were soon the worse for it.

Soon after five o'clock on the morning following the piratical seizure, Moran and Knight, the two sailors held captive, escaped, jumped overboard and swam ashore. Shortly afterwards in a light breeze, away sailed the brig. Two hours later she was out of sight.

When daylight came the marooned parties came together at Green Pt. There was very little food for so many, they were in a sad plight . . . and it began to rain.

Despite Mrs. Carew's entreaties, the pirates had refused to land clothing or other luggage, even for the women and children. The only shelter they had was canvas hammocks spread over boughs of trees. Rough shelters were attempted for the men but they were soon wet through.

John Popjoy, the convict seaman who went with the fishing party was a practical sort of person and appears to have been a most interesting character and apparently a very brave man. Another outstanding personality among the marooned party was the wife of the sergeant. In the

" Colonial Times " we read " that a remarkable instance of the presence of mind in a female occurred, the sergeant's wife, during the confusion, rolled up the despatches intended for Macquarie Harbour and actually succeeded in bringing them off in her apron.".

But to return to John Popjoy. It seems he began to talk matters over with Morgan and they decided to seek permission to try and reach Hobart Town through the bush. They set out and got as far as the Huon River, where they stripped, tied their clothes to their heads and were about to enter the water, intending to swim across when they were attacked by natives. Their exit was extremely hurried and in their anxiety they lost their clothes and in a naked state had to return to the camp at Recherche Bay, two days' journey.

Nothing daunted, Morgan then suggested building a catamaran or coracle in which to paddle along the coast for assistance. The only tools among the party were three pocket knives. With these wattle tree branches were cut and shaped into a boat frame about twelve feet long. Canvas shelters were then stretched over this frame and smeared with a mixture of boiled soap and resin to make them waterproof. Paddles were then fashioned by the help of what remained of the pocket knives.

At noon on 23rd August the crazy little craft was launched, and in her these two brave men, Popjoy and Morgan, set out for assistance. Cheers were given by the castaways, but few of them ever expected to see these two gallant sailors again. And they knew too that they themselves could not live long unless rescue came soon.

Within forty-eight hours help was on the way. First the whale boat from Birch's Bay, with food and other supplies and then the " Opossum " to take them back to civilization. The five men who had set off with the intention of heading the Huon River, found it impossible and in a state of utter exhaustion managed to get within twelve miles of the mouth of the river. Here they were picked up by a search party sent out in a boat from Birch's Bay and were later conveyed to Hobart Town.

Lieutenant Carew was held for Court-martial and charged with neglecting the proper precautions, though warned of the extreme peril which demanded his vigilance; that he proceeded on a fishing excursion; that during his absence the vessel was surprised and seized; that he exhibited professional incapacity and had been guilty of a breach of the articles of war. His trial lasted five days and much conflicting evidence was taken. In the end he was exonerated.

When reporting an account of the trial the " Colonial Times " wrote " Mr. Gellibrand aided Lieutenant Carew by the exercise of his powerful talents and, as we are told, with noble generosity disdained to diminish the family's small store of wealth by taking his customary fee, remarking ' that people who had been stripped of everything, even of clothes as a covering for their children, were not those of whom he ever sought or chose to make a harvest '.". Public sympathy was with Lieutenant Carew and even before the trial, generally he had been absolved of all blame.

John Popjoy, who at the age of eleven years had been transported for horse stealing, was granted an immediate pardon by Governor Arthur as a reward for his outstanding bravery and exemplary behaviour in assisting to rescue the marooned people. Even though confirmation of his pardon could not arrive for some time he was permitted to take the next ship sailing for England, where again he was to render service to those in authority.

The other convicts aboard the " Cyprus " who had not joined the pirates were granted some remission of their sentences, except one and he was promised consideration if during an intervening period no adverse report was received of his behaviour.

In his History of Tasmania the Rev. John West tells that the capture of the " Cyprus " and of the escape of the convicts in her so stirred popular imagination in England that a play was written about it and performed in one of the theatres in London. A song also was written by another sympathiser, and this it is said was for long afterwards sung at many campfires in the interior. Neither play nor song told the story to its end however.

Actually the pirates on the " Cyprus " sailed for the Friendly Islands by way of New Zealand where purporting to be the brig " Darling Brothers " out of Boston they spoke a small vessel called the " Elizabeth & Mary " whose skipper reported the incident on his return to Hobart Town.

From the Friendly Islands, where seven convicts deserted, the " Cyprus " sailed for Japan, then towards China. As they came near the Chinese coast it was decided to scuttle the vessel, take to the boats and endeavour to rehabilitate themselves as the cast-away crew of the " Edward ". How they came to possess a boat from the " Edward ", her sextant and logbook is not clear but they made themselves conversant with her movements as far as the logbook entries would allow.

Two of their number they forced to land on the coast of China but this move in the end was the undoing of the others. The main party then scuttled the " Cyprus " took to the boats and in one of them, that with the " Edward's " name on it, arrived at Canton. Here they survived a close examination, though their demeanor and the style of their narrative gave rise to strong suspicions. There was nothing however which justified their detention. Swallow and three others were given passages back to England at the expense of the Company to which the " Edward " belonged. The others joined a Danish brig about to leave for Mexico.

Not long afterwards the two men compulsorily put ashore arrived at Canton but under the custody of Chinese officers who delivered them to the authorities as British subjects.

At first these two told the same story as their predecessors, but because news of the capture of the " Cyprus " had by then reached China from New South Wales, they were doubted, confined separately and questioned. On 24th June, 1830, one of these men, John Dennie (or Denner) voluntarily made a confession, from which I have taken details. The information he gave was hurriedly sent on to London. It reached England just before Swallow and his companions did. A warrant was issued for their arrest. After some delay they were discovered and taken into custody. Their trial commenced soon afterwards.

John Popjoy, who had come under notice again for committing some trifling offence, was called to give evidence. He told of the pirate's crimes, gave their names, described the secret marks on their persons, all possibly with the idea of saving his own skin; for an opinion had grown then that he deliberately had persuaded Lieutenant Carew to go on the fishing expedition in Recherche Bay chiefly with the intention of giving the pirates a full opportunity to capture the "Cyprus". How or what he was to gain from such an infamous action is of course now difficult to imagine.

Some pirates were sentenced to death, others were transported again to Van Diemen's Land. Among the latter was Swallow, who escaped execution, it is said, because he was ill at the time or it was pleaded that he had not actually engaged in the capture of the "Cyprus". He was taken to Macquarie Harbour, was long confined to hospital, both there and at Port Arthur. His sufferings were extreme and according to the Rev. John Allen Manton, First Wesleyan Methodist Missionary Chaplain at Port Arthur, "he expressed a strong desire for salvation and pleaded hard for mercy". He finished his earthly course on 12th May, 1834.

For long the loss of the "Cyprus" was used as an argument to induce the Government to close Macquarie Harbour Penal Station which in the end was closed in 1834. Then in 1835 a strong effort led by the Sheriff at Hobart Town, was made to bring about the cessation of Transportation altogether; but eighteen years elapsed before popular feeling was strong enough to obtain the desired result and it was not until 10th August, 1853, that the Great Day could be celebrated.

The Metamorphism of the Cambrian Basic Volcanic Rocks of Tasmania and its Relationship to the Geosynclinal Environment

By

Beryl Scott, B.Sc., Ph.D.

(*With 4 Plates and 2 Text Figures*)

Abstract

A spilitic suite comprising picrite basalts, spilites, keratophyres, albite dolerites and associated pyroclastics of Middle and Upper Cambrian age, outcrops on the North-West and West Coast of Tasmania. The spilites and keratophyres are considered to have been normal basalts which later suffered soda metasomatism as a result of geosynclinal deposition and orogeny. Hydrothermal alteration of the volcanics has also given rise to a variety of other rock types which includes porphyries, variolite, spherulitic quartz rock and jasper.

Introduction

While the author was resident in Tasmania, a detailed petrographic study was made of the Cambrian volcanic rocks of the State and the results were submitted to the University of Tasmania as a thesis for the degree of Doctor of Philosophy in 1952. Several papers have already been published on this work (Scott, 1952), but after leaving Tasmania it was thought necessary to publish a general summary of the whole study even though the interpretations may not be conclusive.

Much confusion exists in the literature dealing with the volcanics of the West Coast of Tasmania. The igneous rocks have been referred to as porphyroids, keratophyres, quartz and feldspar porphyries, andesites, melaphyres and syenites. The present author believes that the greater part of the volcanics was essentially basic in composition, probably basalts and porphyritic basalts, with or without amygdales, and their corresponding pyroclastics. The rocks which are seen to-day are the metamorphic products of these. The varying nature and extent of the metamorphism have yielded a great diversity of rock types. It was probably because of an incomplete understanding of the metamorphic processes which were operative that the confusion in terminology arose.

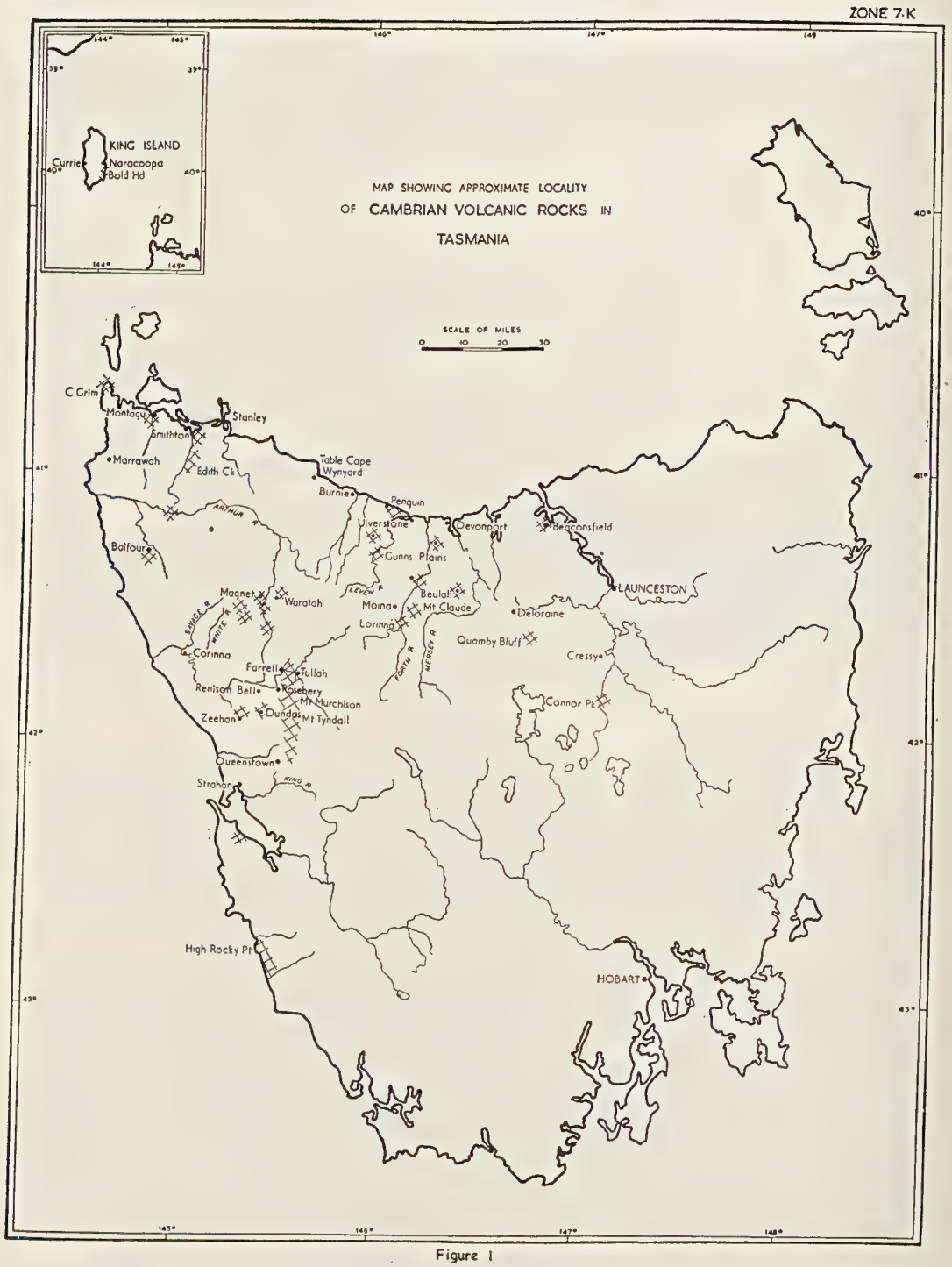

Figure 1

FIGURE 1.—Map showing approximate locality of Cambrian Volcanic Rocks in Tasmania.

Distribution of the Volcanic Rocks

As indicated in figure I these ancient volcanic rocks outcrop intermittently along a belt some 30 to 40 miles in width. This trends in a northerly direction for about 100 miles from High Rocky Point on the south-west coast, through Double Cove on the southern shore of Macquarie Harbour, the Jukes-Darwin District south of Queenstown, Zeehan, Dundas, Rosebery, Mt. Farrell, Tullah and Waratah, thence trending north-east to the Dial Range, Penguin on the north coast and the Leven Gorge. From here it begins to swing south-east, the outer boundary being in the vicinity of Beaconsfield and the inner in the vicinity of Quamby Brook. About Cressy the group is concealed by overlying younger rocks. It seems that this broad band of volcanics trends around the stable Tyennan Block of Pre-Cambrian rocks.

About 30 miles west of Waratah is a narrower band of volcanic rocks. Its width would be in the order of two miles. It extends approximately in a northerly direction through Balfour to Smithton on the north-west coast of Tasmania. Most probably the volcanics of the south-east of King Island, which outcrop from Naracoopa in the north to the Grassy River in the south, belong to this belt. Very little is known about the country in between these bands. Petrologically the rocks in both are similar.

Closely allied with the volcanics are intrusions of basic and ultrabasic rocks which have been serpentinized to varying degrees.

Age and Thickness

The age most commonly given these rocks in the older literature is Cambro-Ordovician, although ages ranging from Cambrian to Devonian have been imposed. It now seems from the fossil evidence of Thomas and Henderson (1945) and Opik (1951), that the volcanics are of Middle Cambrian age.

Elliston's unpublished work on the Dundas District indicates that volcanic material of over 9000 feet in thickness makes up the Dundas Group (Middle Cambrian) in which the Curtin Davis Lavas of approximately 1000 feet in thickness occur. The author believes that most of these tuffs are not true pyroclastics but sedimentary rocks composed of a great deal of transported igneous material and belong to the greywacke suite, as defined by Pettijohn (1949).

Petrography

It is often difficult to determine the original nature of the rocks because of abundant silicification and chloritisation which have affected them. From examination of the least altered specimens, however, it seems that the following types are present.

LAVAS:

Picrite Basalt: At Beaconsfield are lavas which are similar to the picrite basalts of King Island (Scott, 1951). A slide of a specimen, labelled " Western Tasmanian Copper Mine at Beaconsfield " shows phenocrysts of olivine now pseudomorphed by calcite and iron ore. The olivine can be recognised by its crystal outline and irregular cracks along which occurs iron ore. The olivine pseudomorphs show irregularly developed glomeroporphyritic texture. The groundmass is fine grained and contains tremolite needles. Veins containing quartz and calcite traverse the rock.

Porphyritic Pyroxene Basalt: Along Lynch Creek, south of Queenstown, are to be found two fairly thick beds of volcanics. The lower flow is akin to the amygdaloidal Montana Melaphyre or Spilite while the upper flow with its associated breccia is quite different. Even in the greenish-grey coloured hand specimen large idiomorphic phenocrysts of pyroxene can be seen. Under the microscope these phenocrysts exhibit multiple twinning and good cleavage. Sometimes smaller crystals are grouped together to give a glomeroporphyritic effect. The pyroxene is colourless, has an extinction angle of 50° (γ; c), double refraction of 0·030 and an optic axial angle, determined by means of the universal stage, of 52°. Its optical properties indicate a diopsidic augite. The chemical analysis given in Table I confirms the variety of diopside as a salite. Phenocrysts of albite up to 1 mm. in size are also present and show a combination of both multiple and simple twinning. Some of the albite shows alteration to sericite and some to chlorite. The groundmass is composed of laths of feldspar and granules of augite. Amygdales are rare but when present are lined with chlorite and quartz and filled with radiating prehnite or radiating albite with a little quartz.

Basalt: This is the most common type amongst the lavas. It is represented in the Zeehan district by the Montana Melaphyre or Spilite; at Groom's Slip near Penguin and in the Smithton district by a rock very similar to the massive lava of King Island (Scott, 1952). Blake (1936) states: " There is a general similarity between the dolerites of this district (i.e., district between the Mainwaring and Wanderer Rivers) and those found near Smithton in the north-west of the State, even to the inclusion of small flakes of native copper and patches of epidote.". Hence, it may be assumed that the Mainwaring River is another area in which the basalts are found. According to evidence gained from the study of slides it seems that similar rocks are also to be found at Magnet near Waratah, Heazlewood, Penguin, Leven Gorge, Mt. Claude, Mt. Ramsay, north of Mt. Chester, King River, Dundas and Double Cove. Most probably the basalt occurs elsewhere but generally what are found to-day are its silicified equivalents.

Microscopically the Montana Melaphyre is light-grey in colour and contains numerous ovate amygdales containing dark-green to black chlorite. These amygdales range in size from less than 1 mm. to almost 10 mm. in length while the average is about 2 mm. Traces of silicification are evident.

TABLE I—ANALYSES AND OPTICAL PROPERTIES OF PYROXENES

	a	b	c	d
SiO_2	48·53	50·23	45·86	48·77
Al_2O_3	7·10	5·29	8·30	4·18
Fe_2O_3	0·70	1·16	2·08	2·03
FeO	5·71	4·48	7·03	9·34
MgO	15·99	14·74	12·65	12·48
CaO	21·24	20·50	20·23	20·49
Na_2O	n.dt.	0·70	0·68	0·51
K_2O	n.dt.	0·10	0·11	0·02
H_2O+	n.dt.	0·66	0·54	0·98
H_2O-	n.dt.	0·03	0·02	
TiO_2	0·85	0·92	2·34	1·59
P_2O_5	n.dt.	0·05	0·05	nil
MnO	n.dt.	0·25	0·17	0·11
CO_2	n.dt.	0·68	0·20	—
	100·12	99·79	100·26	100·50
Optical Data—				
α	1·69 (dt. graph)	1·685	1·707	1·699
β	n.dt.	1·690	1·714	1·706
γ	1·72 (dt. graph)	1·706	1·727	1·722
$\gamma-\alpha$	0·030	0·021	0·020	0·023
$2V(+)$	51°	49°	38°	52°
γ; c	50°	53°	55°	44°
Sp. Gr.	3·307	—	—	—
Atomic %—				
Ca	46·7	47·5	48·3	46·8
Mg	42·3	43·4	36·6	34·2
Fe	11·0	9·1	15·1	19·0

a. Pyroxene from Lynch Creek Lava, South Queenstown, Tasmania. Anal. B. Scott.
b. Pyroxene from olivine basalt (Lower Carb.) from Old Pallas area, Co. Limerick. Ashby (1946), p. 196.
c. Pyroxene from olivine basalt (Lower Carb.) from Old Pallas area, Co. Limerick. Ashby (1946), p. 196.
d. Pyroxene from trachybasalt (Lower Carb.) from Old Pallas area, Co. Limerick. Ashby (1946), p. 196.

TABLE II—FORMULA OF PYROXENE

Z	Si	1·785	i.e.,	Z = 2·00
	Al	0·215		XY = 2·030
Y	Al	0·094	or	
	Ti	0·022		
	Fe‴	0·018	$Ca_{0·839}$ (Al, Ti, Fe‴, Fe″, Mg) $_{1·191}$ $(Si, Al)_2O_6$	
	Fe″	0·174		
	Mg	0·883		
X	Ca	0·839		

Similar rocks occur at Beulah, Beaconsfield and Mackintosh River. Perhaps the augite porphyrite at Smithton described by Nye, Finucane and Blake (1934) would also belong to this group.

Microscopically the rock consists of numerous lath shaped crystals of feldspar up to 0·5 mm. long which have been stained brown. The remainder of the rock is composed of small patches of carbonate, chlorite, quartz and fine acicular crystals and tiny grains of iron ore. No primary

ferromagnesian mineral is present and it appears to have been replaced by the carbonate and quartz. Under very high power tiny pseudomorphs of chlorite after olivine were observed, the identification of olivine being based on crystal outline only. The feldspar is now albite and generally shows no twinning. It is partly altered to carbonate, chlorite and quartz and sometimes is surrounded by very small granules of iron ore. The amygdales are usually filled with chlorite, often with a concentric arrangement, or calcite. In some cases the amygdales are lined with chlorite and then filled with calcite, while the two minerals may occur together, concentrically arranged. Quartz, too, is known to occur with these minerals in the amygdales. Related rocks differ from this general description by the presence of abundant chlorite with a little quartz and/or calcite filling the interspaces between the feldspar laths. Granules of sphene and ilmenite are quite common. Sometimes the pyroxene has been replaced by green pleochroic hornblende with some chlorite while in rocks from localities such as King Island, Smithton and Penguin fresh pyroxene still remains. When altered, it has been attacked around the edges and along the cleavage and changed to a brown unidentified material and green chlorite.

Porphyritic Basalt: This appears to be a common rock type in the Magnet district and resembles the melaphyre to some extent. It is often amygdaloidal and contains large tabular phenocrysts of albite up to 3 mm. in length which are now partly sericitized.

The Curtin Davis Lavas which are well exposed near the Montezuma Falls near Dundas belong to this group. As well as being porphyritic they are amygdaloidal. The phenocrysts of feldspar which are idiomorphic to subidiomorphic have been replaced by chlorite, carbonate and quartz while the groundmass which once perhaps consisted of laths of plagioclase and granules of augite, now has its minerals replaced by chlorite, quartz and carbonate in different proportions. When the rock has been slightly sheared and more silicified and chloritized it is difficult to distinguish the phenocrysts from the groundmass under crossed nicols.

Glassy Basalt: Evidence of the existence of glassy lavas is revealed throughout the West Coast. The breccias and tuffs commonly contain fragments of devitrified glass.

In the Leven Gorge there are flow rocks which were once glassy. They contain a few laths and skeletal phenocrysts of feldspar up to 8 mm. in length. In some specimens the feldspar has been silicified while in others it is sericitized. The groundmass is extremely fine grained and its constituents are almost irresolvable but seem to be chlorite, feldspar and iron ore. In one specimen the devitrification has caused the appearance of spherulitic structure.

Feldspathic Basalt: Occurring in the Smithton District and Leven Gorge are very feldspathic basalts consisting of laths of albite (Ab_{95}) up to 0·5 mm. in length. The albite shows good multiple twinning and some crystals show interpenetration twins. The edges of the laths have a nibbled appearance. Between the feldspar is a little quartz and chlorite. A few granules of sphene and ilmenite are present. Sometimes the rock is slightly porphyritic when some of the larger crystals of albite form phenocrysts.

With an increase in chlorite and iron ore this rock passes into the normal basalts and all gradations between the feldspathic basalt and true basalt exist. It may be that the Montana Melaphyre is more closely related to this group than the more basic basalts.

PYROCLASTIC ROCKS:

Extensive developments of tuffs and breccias from localities throughout the West Coast have been described in the bulletins of the Geological Survey of Tasmania. However, in light of recent detailed work on the rocks in this district which has revealed great quantities of greywackes, it may be that most of the tuffs and breccias described by the earlier workers should be classed as greywackes.

Wherever the lavas were examined in the field, the author found evidence of pyroclastic rocks in the form of tuffs and breccias. These have been described from King Island (Scott, 1951), and volcanic breccias and bombs have been described from Smithton (Carey and Scott, 1952).

Breccias occur along Lynch Creek, South Queenstown, and along the Trial Harbour Road at Zeehan. In the former locality the breccia is composed of numerous fragments of volcanic rock, up to three inches in size, which have been caught up in the lava. The fragments contain idiomorphic phenocrysts of feldspar, now pseudomorphed by sericite, together with a fresh pyroxene set in a devitrified glassy groundmass. Amygdales are filled with quartz, chlorite and a little sericite. The fragments appear to be the glassy equivalents of the lavas and represent portions of a quickly chilled upper surface of the lava flow which were caught up in the body of the lava after the chilled crust had been fractured by pressure from the flowing lava. At Zeehan a somewhat similar rock occurs. Associated with flows of the very amygdaloidal melaphyre is a breccia which is composed of fragments of melaphyre within melaphyre. In spite of their brecciated appearance the term breccia is not strictly applicable to these rocks as they are really lavas containing numerous cognate xenoliths.

Most of the breccias and tuffs examined by the author consist of fragments of quartz, plagioclase (which, wherever determined proved to be albite), and basic lava, some of which has been glassy, set in a fine grained matrix which is generally feldspathic and siliceous showing patches of carbonate and chlorite and grains of iron ore, either magnetite or ilmenite.

Nye, Finucane and Blake (1934) describe a tuff from Duck Bay, Smithton. Nye (1923) describes two varieties in the Waratah district; a feldspathic breccia without mica and a micaceous breccia interbedded with slate. Nye, Finucane and Blake (1934) record the occurrence of similar breccias in the Smithton district but state that instead of these two distinctive types being present there are gradations between the two.

DYKE ROCKS:

Earlier writers such as Twelvetrees (1900), Nye (1923) and (1931), and Nye, Finucane and Blake (1934) regarded large occurrences of the volcanic suite as dolerite dykes.

The work of Nye, Finucane and Blake on the Smithton dyke has been reinterpreted by Carey and Scott (1952) who now regard the dyke as a suite of extrusive volcanic rocks including pillow lavas and volcanic breccias. Likewise in a recent publication by Scott (1952), the dolerite of Lower Palaeozoic age reported by Nye (1931) from Groom's Slip near Penguin has been reinterpreted as portion of the volcanic suite on the basis of the occurrence of pillow lavas and their association with tillite (?) and finely laminated shales.

Twelvetrees (1900) and later Nye (1923) described the Magnet Dyke which outcrops for about five miles in a north easterly-south westerly direction a few miles west of Waratah. The dyke, according to the writers, has an average thickness of about 200 feet and is very complex. It consists of " websterite porphyrite " which has been dolomitized towards the eastern margin, then " diabase porphyrite " which contains bands of " variolite " followed by " spherulitic websterite porphyrite ". Inclusions of slates and quartzites belonging to the " Bischoff Series " have been described by Nye (1923) as occurring in the dyke between the " websterite " on the east and the " diabase porphyrite ". This dyke was a problem to the writers as they were puzzled about the relationship of the " diabase porphyrite " to the " websterite porphyrite ". The conclusion reached was that the " variolite " was probably a magmatic variation of the " diabase porphyrite ", which was intruded along a fault plane in the earlier intruded " websterite porphyrite ".

After reading the literature and examining many slides of the rocks from the Magnet Dyke in the collections of the Mines Department and University, the author doubts the validity of the interpretation of the diabase porphyrite as a dyke for the following reasons:—

1. The outcrop of the alleged dyke lies in the general belt of known volcanic rocks of the West Coast.
2. There is general petrographical similarity with known volcanic rocks (e.g., Montana Melaphyre, King Island lavas, &c.) based on the—
    - (i) general fine grained basaltic appearance as well as the existence of coarser varieties, as elsewhere.
    - (ii) abundance of amygdales which seems too great to be consistent with an interpretation as a dyke rock.
    - (iii) hydrothermal alteration similar to the Montana Melaphyre, even to the formation of spherulitic quartz rock.
3. The presence of volcanic breccia.

Twelvetrees (1900) reports " Subsequent to the middle Silurian, basic and ultrabasic eruptions or intrusions took place, penetrating and displacing the buried sedimentary strata, and forming subterranean masses and dykes of gabbro, peridotite and pyroxenite. There is no evidence that these deep seated eruptions ever reached the surface, for we see no ancient basalts in this area, unless the diabase porphyrite at the Magnet Mine is regarded as a lava sheet." The diagram in this report shows the diabase porphyrite is concordant with the associated sediments.

Dense secondary growth of vegetation now renders the area almost impenetrable and obscures the outcrops and although most of the rock types recorded by the earlier writers were found by the author, it was impossible to establish their relationship with each other. It must be remembered that the slides examined by the present author were cut from rocks brought out from the workings during mining operations. Most of the information stated by Twelvetrees and later reproduced by Nye was gained from the observations in the adits.

During an examination of the area the author found no conclusive evidence but the petrological evidence indicates that the dyke is a portion of the volcanic suite.

Associated with the volcanic rocks in most areas where they outcrop is what older writers have termed diabase. To use modern nomenclature, this dolerite is probably the hypabyssal equivalent of the basalts and occurs as cognate dykes and sills. As in the volcanic rocks the plagioclase has been greatly altered to albite, chlorite and sericite. The augite is often fresh but when altered the alteration product is usually chlorite and very occasionally hornblende as in the Leven Gorge dolerites.

Hydrothermal Alteration

The outstanding feature of these old Cambrian volcanic rocks is their hydrothermal alteration which has given rise to a variety of rock types, some of which are quite unusual and are described below. The chief types of alteration seem to have been albitization, silicification and chloritization.

Albitized Basalt.

This is the simplest rock type developed. As on King Island, at Smithton and Penguin it is quite common to find the pyroxene practically unaltered. The only major form of alteration is the albitization of the plagioclase which may also show partial alteration to sericite and chlorite.

Albitized and Chloritized Basalt.

In this basalt the plagioclase has been converted to albite and the pyroxene to green chlorite which now occupies the spaces between the albite laths. The albite often shows further alteration to sericite and chlorite while the chlorite is often accompanied by granules of sphene. Sometimes quartz with needles of tremolite may be observed in association.

Silicified, Carbonated and Chloritized Basalt.

A very amygdaloidal basalt from Magnet has been completely changed to a rock containing quartz, carbonate and chlorite while the circular amygdales have been filled with chlorite. Not one of the original constituents remains.

Siliceous Spherulitic Rock.

Siliceous spherulitic rocks are known from the Montana area at Zeehan. Boulders have also been found in the Castray River, a tributary of the Pieman, and in the Arthur River where it is crossed by the Magnet "dyke", indicating that the same rock may also crop out some 30 miles

north of Zeehan. Twelvetrees and Ward (1910) gave a description of the occurrence on Montana Flat. The author does not wish to redescribe the rock but to put forward a view as to the possible formation of the spherules. This view arises from the observation of a sequence of stages in the development of the spherules by examining a suite of closely related rocks in the vicinity.

A less silicified specimen found a few feet from the spherulitic rock in the same trench on the Montana Flat is very dark greyish green in colour with light coloured spherules, averaging about 5 mm. in diameter, scattered through it. In a thin section it is seen that small laths of feldspar are partially replaced by quartz and chlorite. Quartz is developed between the laths and seems to have taken on a feathery form and a tendency to spherulitic texture as illustrated in figure 1, plate I. Always accompanying the quartz is chlorite, probably pennine, which is also developed together with iron ore, sphene and quartz between the embryo spherules. Often iron ore outlines the pseudomorphs after the feldspar amongst the chlorite.

A similar rock, incorrectly named a chloritized actinolite schist from the Lucy River and also the variolite associated with the diabase porphyrite described by Twelvetrees (1900) in dealing with the so-called Magnet Dyke, were similar alteration products of the diabase porphyrite.

On pp. 83-85 of Bulletin 33 of the Geological Survey of Tasmania in a description of the ore body of the Old Jasper Mine, there is a reference to a " pseudo-amygdaloidal " variety of hypersthenite. No doubt the slide from the Mines Department labelled " Amygdaloidal pyroxenite " from No. 3 Adit of the Old Jasper Mine is an alteration of the old lavas. The white patches have taken on a form as in the spherulitic rock but the material in between is still mainly chlorite with some carbonate, quartz and albite. Some of the white nodular patches are of radiating albite which shows slight alteration to kaolin, good cleavage and multiple twinning.

Nye (1923) included in his report a detailed description of a microscope slide of the variolite by Professor Rosenbusch which was originally recorded by Twelvetrees in his report of 1900, hence redescription here seems unwarranted.

At Zeehan and Magnet this so-called variolite and the spherulitic rock are intimately related to the Montana Melaphyre and diabase porphyrite respectively, i.e., with old basalts, both amygdaloidal and porphyritic. The following is an outline of the suggested formation of the spherules:—

1. The spherulitic rock is probably derived from a more basic lava such as the Montana Melaphyre in which the first stage is the development of quartz, chlorite and sometimes carbonate between the feldspar laths, i.e., a break-down of the pyroxene.
2. The quartz takes on a feathery form with spherulitic tendency (figure 1, plate I) while the chlorite is pushed out to between the embryo spherules.

3. With the addition of more silica, complete spherules are developed with fringes of radiating quartz and with fine granular quartzitic material between. This is illustrated in figure 2, plate I.
4. The radiating fringes grow outwards from the spherules at the expense of the fine granular material which they incorporate. These fringes continue to grow until all the granular material has been consumed and a perfect spherule is developed in the area formerly occupied by the minute grains of quartz. Figure 1, plate II, illustrates this phenomenon.
5. In some cases the fine grained material increases in grain size and finally unites and at the same time the radiating fringes grow out. It has been noted, as indicated by figure 1, plate III, that at the junction of the two a crack develops.
6. Figure 2, plate III, illustrates the final development of the spherulitic rock which is the stage when all the spherules are close together with no granular material between them.

The formation of the secondary spherules represents an interesting case of silica metasomatism. Below are analyses (Table III) of rocks from different areas representing the various stages of alteration. It is assumed that the original lava was somewhat similar in composition to the least altered lavas of King Island. This is illustrated by the variation diagram (figure 2).

TABLE III

	I	II	III	IV
SiO_2	50·01	60·00	73·00	99·11
Al_2O_3	15·38	11·97	9·95	nil
Fe_2O_3	4·86	7·68	5·29	0·75
FeO	9·21	0·39	0·39	Tr.
MgO	5·85	6·50	3·84	nil
CaO	6·53	4·35	2·30	nil
CO_2	0·13	8·90	5·90	nil
FeS_2	—	0·24	0·57	nil
	—	100·03	101·24	99·86

I. Spilite (basaltic type), King Island, Tasmania. Anal. B. Scott.
II. & III. Variolite from Magnet Mine, Tasmania (different portions of same specimen). Anal. Geol. Surv. Lab. (Bulletin No. 33.)
IV. Spherulitic quartz rock, Montana Flat, Tasmania. Anal. B. Scott.

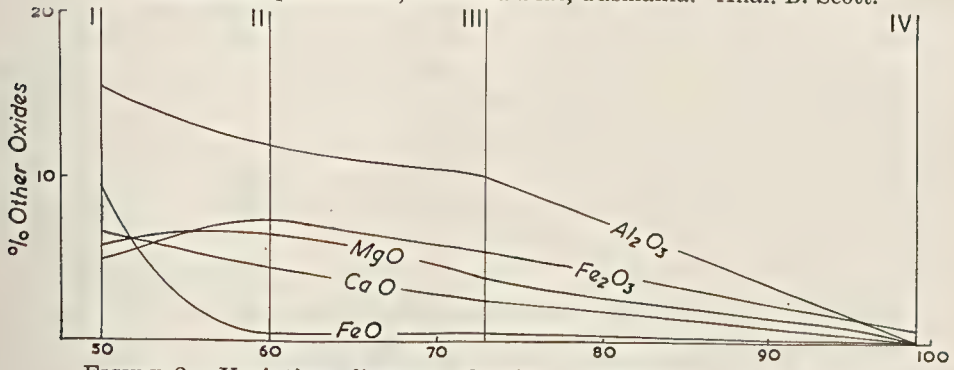

FIGURE 2.—Variation diagram showing development of secondary spherules in basic rocks.

Porphyries.

In numerous localities in the West Coast area are quartz, quartz feldspar, syenite and granite porphyries. They have been classified by various writers as being intrusive or metasomatic (i.e., metasomatically altered sediments and volcanic rocks). The author does not wish to deal with the formation of the porphyries in detail as this is being done by a colleague, Mr. J. Bradley, formerly of the Geology Department, University of Tasmania. She is only interested in them in so far as they are related to the volcanics.

There is undoubted evidence that some of the volcanic rocks, both lavas and associated pyroclastics, have given rise to the development of " porphyritic " (i.e., porphyroblastic) rocks. This, however, does not mean that all the porphyries were originally volcanic. In fact there is evidence of sediments being " porphyritized " too. The region of greatest development of these rocks is at Queenstown (Mt. Lyell) and Read-Rosebery district along the crest of the Porphyroid Anticlinorium.

The alteration begins by a replacement of the original rock by quartz and albite to form a very finely granular quartz albite mosaic rock. With further silicification some of the quartz grains seem to coalesce and eventually take on the appearance of a quartz " phenocryst " even to the extent of the development of well defined crystal faces (see figure 2, plate IV). It is not uncommon to find such idioblasts surrounded by very fine (finer than the groundmass material) granules of quartz as though the quartz had to be as fine as possible before it could be absorbed or " digested ". Likewise, as soda metasomatism advances albite " phenocrysts " are developed from the minute granules of the groundmass.

Not only idioblastic quartz and albite but also hornblende seems to grow into well shaped porphyroblasts by a similar process. Specimens of rocks collected by Banks along the Tyndall Track near Lake Margaret were examined. According to Banks, the rock in the field shows evidence of flow structure in the alignment of hornblende " phenocrysts " and contains many cognate inclusions.

In the hand specimen the rock consists of idioblastic crystals of fresh hornblende up to half an inch in length, and smaller crystals of feldspar in a grey stony groundmass. On first appearance it could be classed as a hornblende andesite. In thin section the rock consists of these large idioblasts of green hornblende which show good cleavage, strong pleochroism and both simple and multiple twinning, abundant " phenocrysts " of plagioclase and a few of quartz and orthoclase in a fine grained groundmass. Observation of a number of slides indicates that the groundmass varies. Sometimes it is composed of tiny laths of feldspar with chlorite, carbonate and granules of sphene, in others it is predominantly feldspathic with some quartz while in still others it is predominantly quartzitic with some feldspar. With an increase in quartz in the groundmass there is an increase in quartz " phenocrysts ". These quartz " phenocrysts " seem to be secondary and always show the " replacement borders ". (See figure 1, plate IV.) The plagioclase is albite (approximately Ab_{95}) and shows slight alteration to sericite. Just how much of the plagioclase originally belonged to the lava and how much

is secondary is impossible to say. The porphyritic lavas which are fairly common on the West Coast contain phenocrysts of both augite and plagioclase but there is evidence that some of the "phenocrysts" of albite are secondary. They too show the replacement border.

There is evidence to suggest that this rock did not originally crystallize as a hornblende andesite but as a porphyritic basic pyroxene lava (cf. Lynch Creek type) which has since been greatly altered. This evidence is given by the presence of augite which is in various stages of alteration. The first change appears to be in the formation of chlorite around the edge and along the cleavage planes and cracks of the augite. As alteration proceeds tiny granules of sphene, epidote and even a little iron ore are developed. A later stage is the complete pseudomorphism after the idiomorphic augite by chlorite and sphene. In the end stage hornblende is born out of these alteration products. The power of crystallization is apparently great because soon afterwards idioblastic crystals are developed. Sometimes patches of the unincorporated alteration products are left as inclusions or "embayments" in the hornblende and inclusions of idiomorphic albite crystals are quite numerous. It seems that the hornblende originated as tiny needles which gradually coalesced to give a plate of the mineral. Fringes of the hornblende which have a similar optical orientation to that of the idioblasts may be traced. In some cases hornblende is the direct alteration product of the augite and in ordinary transmitted light it is often difficult to distinguish it from chlorite with which it is closely associated. In fact, one mineral seems to merge imperceptibly into the other.

The mode of origin of this rock is very controversial. According to Hatch, Wells and Wells (1949), the hornblende of hornblende andesites is usually the brown "basaltic" variety and generally shows that it is not in equilibrium with the magma because all degrees of magmatic resorption are displayed. They say "At an early stage this may amount to no more than a slight 'peppering' with magnetite granules, but at a later stage of alteration the hornblende is progressively replaced by an aggregate chiefly consisting of granules of nearly colourless clinopyroxene and octohedra of magnetite". After critically examining thin sections of this rock the author is of the opinion that the reverse is true. The clinopyroxene, a stable diopside augite, is in keeping with the variety suggested as being typical of andesites.

The alignment of the hornblende "phenocrysts" is suggestive of a primary origin but the petrographical evidence is against this. The pyroxene which is usually stable shows more alteration than the usually less stable hornblende. The needles of hornblende, optically oriented similarly to the rest of the hornblende, cut across what some authorities would regard as the alteration products of the hornblende. If the hornblende is secondary after pyroxene then the pyroxene originally was oriented in the direction of flow. Only in a few places is the hornblende directly replacing pyroxene; more commonly it is formed by the metamorphism of alteration products of pyroxene (chlorite, epidote, &c.). If the pyroxene had been originally oriented, then the hornblende would have grown with the same direction, yet in most cases none of the original mineral was left to control the direction of growth of the new mineral.

Another suggestion is that the orientation of the hornblende crystals may be a metamorphic effect but the rocks in general do not exhibit structures indicative of dynamic metamorphism. According to Banks the direction of alignment is at an angle to the cleavage. If, as the author thinks, this rock is not a true hornblende andesite the orientation of the hornblende remains unexplained.

In the Mines Department is a slide, cut from a rock from the Que River, labelled " Feldspar Quartz Porphyry ". It is an interesting rock, because in the groundmass are remnants of the fine grained basaltic lava. Phenocrysts of both augite, some showing slight alteration to chlorite and epidote, and albite are present in a groundmass containing quartz, feldspar, chlorite and granules of sphene. A similar rock, which is amygdaloidal, occurs at Farrell Siding. In this case the pyroxene has been pseudomorphed by a carbonate or quartz and carbonate.

The author does not wish to be dogmatic and state that all the porphyries and porphyrites of the West Coast of Tasmania are of secondary origin. She does suggest, however, that those so-called " porphyroids " and augite porphyrites which contain phenocrysts of augite of the salite variety and albite with or without quartz in a feldspathic groundmass are to be suspected of having a secondary origin. Earlier workers have regarded rocks having albite and augite (both considered primary) as occurring in minor intrusions and representing the acid differentiate of the basic and ultrabasic rocks.

Keratophyres.

The terms porphyry, porphyroid, keratophyre and felsite have been indiscriminately applied in the past. Similar rocks have been given any of the above names. After examining many specimens and microscope slides of these rocks the author is at a loss to determine the criteria on which these distinctions were based. If the term porphyroid is used as it was originally meant then some of these rocks could correctly be referred to as porphyroids because many are sheared and some of the phenocrysts even have a " rolled out " appearance.

Twelvetrees and Petterd (1899) describe some of the felsites and associated rocks of the Mt. Read district. They considered the rocks to be lavas which were contemporaneous with the argillaceous sediments which are now converted to schists. These authors sent specimens to Professor Rosenbusch for confirmation of naming. The following description was returned " Undoubtedly we have here strongly dynamically altered forms of the acid eruptive rocks. The typical porphyritic structure, the nature of the phenocrysts, the still recognisable fluidal structure, the nearly entire absence of dark constituents, the occasional spherulitic forms still recognisable in their replacement products (quartz, albite) all point with certainty to members of the quartz porphyry family, and with great probability, not to quartz porphyry in the narrower sense, but to quartz keratophyre and keratophyre."

Ever since then similar rocks and even dissimilar associated rocks have been classed as one of the rock types mentioned above, without any other reason.

In summarizing their descriptions they say, " The rocks have a compact quartz-feldspathic (felsitic) groundmass, with quartz and orthoclase and albite phenocrysts, sometimes distributed sparingly, at other times so crowded as almost to lose the porphyritic stamp. In the typically porphyritic varieties are altered spherulites and signs of flow structure.".

In all the specimens examined by the author she failed to note spherulites (excluding the spherulitic quartz rock) or true flow structure. Actually the apparent flow structure is a pseudo flow effect and is very misleading. It is really a schistose structure as indicated by the direction of the sericite streaks. Often these streaks curve between the " phenocrysts " which, being brittle, commonly exhibit fracture although some of the feldspars have been " rolled-out ". In the field, the weathering of the schistose structure resembles flow structure but when sections of the rock are examined the schistose nature is readily recognised.

Diopside augite has been observed in some of the so-called keratophyres. Mawson and Dallwitz (1944) correlate similar rocks from south-eastern South Australia, in which pyroxene is present, with the Tasmanian porphyroids. To the author, the presence of such a pyroxene, and especially one of identical composition to that which is prevalent in the associated basaltic rocks, is anomalous. One would not expect to find such a pyroxene in keratophyres if they are soda rich trachytes.

The formation of these keratophyres seems to be similar to that of the porphyries outlined in the previous section. Some original acid volcanic rocks may have existed. If they did, it is now impossible to distinguish them from the highly metasomatized basaltic rocks. However, it is interesting to note that on King Island, at Smithton and Groom's Slip, near Penguin, where the least altered basaltic rocks occur, no acid eruptives comparable with a keratophyre have been found. Also, the keratophyres seem to be restricted to the zone of structural weakness where metasomatism has probably been at its maximum. It seems reasonable to suggest that if true acid volcanic differentiates existed, a trace of them would have been found with the freshest basaltic rocks.

Jasper.

Jasper bands are commonly associated with the lavas in most localities where they outcrop and have been recorded in the literature.

At Groom's Slip, just east of Penguin, where the lavas outcrop strongly along the coast, they are associated with regularly shaped blocks, bands and irregularly shaped patches of red jasper. Some of the bands are up to about eight feet in length and about one to two feet wide. The jasper is the usual red colour and is very finely crystalline. Sometimes it carries a considerable amount of pyrite and in places is associated with green epidote. Thureau (1881) noted the presence of " hornstone " and jasper at Penguin and Twelvetrees (1903) reports the occurrence of jasper from a shaft in the Heazlewood district.

As well as bands of jasper, abundant veins of quartz cut irregularly across the lavas in all localities.

The occurrence of jasper with basic lavas is not restricted to Tasmania. Skeats (1908) records the association of jasperoid material with the Heathcotian rocks in Victoria. In fact, the association of jasperoid rocks is reported from many localities in the world from which spilitic rocks are recorded.

The origin of these jasper rocks is not known. Skeats (1908) regards them as one of the forms of silicified "diabase". Because of the evidence of the formation of the spherulitic quartz rock, which is perhaps a modification of the jasper, the author is in agreement with Skeats and regards them as being the silicified equivalents of the old lavas, especially as they are associated with each other so intimately. In contrast to a number of writers who regard these thick extensive beds of chert with which spilitic lavas so frequently are associated as being precipitated from silica expelled from the lavas, the author believes that the lavas under discussion have gained silica from an extraneous source.

Nature and Origin of the Chemically Active Solutions.

In the paper on the volcanic rocks of King Island, the author dealt with the facts of the hydrothermal solutions as they presented themselves and drew conclusions from these. However, the study has been confined to a small area and later work which has been done on a broader area now indicates that the conclusions drawn from the King Island study do not hold in general for the Cambrian volcanic rocks of Tasmania.

As mentioned earlier, the predominant types of alteration are albitization, silicification and chloritization, and imply the addition of soda, silica and alumina. Many theories have been put forward to explain the origin of albite in spilitic rocks. The possible processes may be classed as primary, deuteric or secondary. For the albite to be of either primary or deuteric origin one must postulate a soda rich magma as in either case the soda belongs to the magma, whether it crystallized early in the form of a primary sodic plagioclase, or later, when in the form of a soda rich solution it affected the earlier plagioclase and converted it to albite. However, on the West Coast of Tasmania not only the lavas but their associated rocks appear to have been albitized so one must look further afield than the lavas for the source of soda. This fact is also borne out when the relative time of alteration is considered. Albite is the only plagioclase present in the lavas which are associated with a suite of greywackes also containing albite. In view of the mode of formation of greywackes, i.e., rapid erosion and deposition in a geosyncline, the albitization must have taken place either before the formation of the greywackes, in which case the albite was derived as such from the lavas, or after their deposition. Chlorite and other secondary minerals associated with the albite are abundant in the greywackes as in the lavas indicating that albitization followed deposition. It seems then that a secondary origin for the albite is assured.

Carey (pers. comm.) suggested to the author that the soda rich lavas on the West Coast of Tasmania (possibly spilites in general, the world over) were not derived from a soda rich magma but were normal basalts which were later albitized, the albitization being due to burial in a geosyncline. Other factors in the suggested alteration were the thickness

of geosynclinal sediments underneath the original basalts, the temperature reached by the base of the sedimentary prism and the permeability distribution in the geosyncline, the temperature being considered the most important of all. It was also suggested that it was unnecessary to go beyond the geosynclinal rocks for an adequate supply of soda and silica. A redistribution of the normal content of these constituents in the sediments is sufficient. In the pre-eugeosynclinal phase of most geosynclines there may be appreciable thicknesses of orthoquartzites and other highly siliceous rocks which yield their surplus silica to subsequent migrant fluids. The soda content of the initial connate water seems sufficient to account for the albitization while the alumina could be an excess constituent from some of the pelitic sediments.

After careful consideration of the many possibilities as to the origin of the hydrothermal alteration, the author agrees that the soda metasomatism which has affected the basaltic rock is due to a geosynclinal environment. Although depth of burial may be an important factor, it does not entirely control the proportion of alteration. In the miogeosyncline of South Australia where the basalts of a somewhat similar age are associated with 40,000-50,000 feet of sediments they have only spilitic tendencies, yet in the eugeosyncline of Tasmania where the lavas are associated with 10,000 to 20,000 feet of sediments they have been completely albitized.

The solution could not have been above its critical temperature and pressure because of the assemblage of minerals produced. The assemblage of minerals—albite, chlorite, carbonate, quartz, &c.—developed as a result of metasomatism is not indicative of high temperature formation. It could be formed readily at temperatures below 300° C.

The formation of hydrogrossular, which is rather restricted, requires a higher temperature (see Scott, 1951) but on King Island where it is developed, the intrusion of granite of Middle Devonian age could perhaps account for the higher local conditions of temperature. The formation of hornblende in the porphyries and the lavas also possibly requires a slightly higher temperature. Petrographical evidence indicates that hornblende developed after the low temperature alteration so it may have been formed during the rising crescendo of the Tyennan (late Cambrian) Orogeny or, since it is developed most strongly in rocks along the structural weakness, any rise in the temperature below (possibly during the Tabberaberan Orogeny) could be transmitted readily to the rocks above.

Relationship of the Metasomatism to Geosynclinal Deposition and Orogeny

The group of sediments with which the volcanic rocks are associated is typical of eugeosynclinal deposition. The sediments were deposited in the Dundas Geosyncline which is peripheral to the Tyennan Block composed of Pre-Cambrian rocks (Carey, 1953, p. 1115). This geosyncline contains about 11,000 feet of Cambrian cherts, slates, conglomerates, volcanics and greywackes, the latter being derived for the most part by rapid erosion and deposition from the basic volcanic rocks. In addition to the Cambrian, there are, in the geosyncline, several thousand feet of Ordovician, Silurian and Lower Devonian strata.

The Tyennan uplift which commenced in the early Middle Cambrian and continued throughout the Upper Cambrian was coeval with the Dundas sedimentation, according to Carey (1953). It was probably during this orogeny, particularly in its latest stages when the accumulation of sediments was greatest, that metasomatism took place. The metasomatic alteration resulted in widespread albitization and silicification accompanied by other changes such as chloritization and epidotization which required additional alumina, no doubt provided from pelitic sediments. This metasomatic alteration was responsible for the formation of the spilitic rocks and porphyroids. The alteration was differential because the rocks are altered to various degrees. In places it has been so advanced as to give rise to the formation of granites (e.g., Darwin granite) and syenite such as in the Murchison Gorge south of Mt. Farrell. The greatest development of the " porphyroid " group is approximately along the crest of the West Coast Range anticlinorium which was rising during the last phases of the orogeny.

If a very general picture of the structure is considered, there appears to be a kind of zonal arrangement in the metasomatism of the lavas. These zones are as follows:

1. A zone along the Porphyroid Anticlinorium where soda metasomatism was predominant together with silicification resulting in the formation of the porphyries and keratophyres.
2. West of the zone, through Zeehan, Magnet and Leven Gorge is a zone where silica metasomatism predominated.
3. Further west still, through High Rocky Point, Smithton and King Island is a zone of very little alteration apart from albitization.

Evidence that this phase of metasomatism was completed before the deposition of the basal beds of the Junee Group (Lower Ordovician) is revealed by the presence of boulders of Darwin granite (reported by Hills, 1914) and " porphyroid " (verbal communication by Banks) in the West Coast Range Conglomerate.

However, there was another more violent period of orogeny, the Tabberabberan, of Middle Devonian age, which was also accompanied by a period of hydrothermal alteration. This period of alteration was responsible for the widespread silicification of the West Coast Range Conglomerate.

During the Tabberabberan Orogeny an important very deep shear, which in places has its surface expression in a fracture and elsewhere as a zone of overturned attenuated strata was developed, according to Carey (1953). This overturned and attenuated zone is associated with local sericitization and with numerous hydrothermal ore bodies.

The so-called hornblende andesite from the Tyndall Range near Lake Margaret is very close to this shear zone. It is possible that the development of the hornblende which, as indicated in a previous section, probably needed a slightly higher temperature of formation and followed the low temperature alteration, may belong to this second period of metasomatism.

Most probably the earlier formed porphyroids suffered further alteration and shearing. Two periods of alteration are suggested by petrographic evidence and it is interesting to note that the second period gave rise to the development of more quartz than albite.

Carey (1953) is inclined to believe that the silicification of the lavas in the Zeehan-Magnet district took place during the Tabberabberan Orogeny. Certainly, this and the silicification of the lavas to jaspers near Penguin (found since the writing of Carey's paper), fit into his structural pattern, but apart from this the author has no definite evidence to indicate to which orogeny it belongs. Since silicification is a common phenomenon associated with spilites elsewhere in the world she is inclined to think it may belong to the Tyennan Orogeny, thus completing the " spilitization " in the one period.

Summary and Conclusions

An attempt has been made to elucidate the nature and metamorphism of the Cambrian volcanic rocks of Tasmania which outcrop predominantly over a wide area on the West Coast of Tasmania and along the south-east coast of King Island.

The most important points to be drawn from the study are as follows:

1. The volcanics comprise a spilitic suite consisting of picrite basalts, spilites, keratophyres, albite dolerites and associated pyroclastics which were erupted into the Dundas Eugeosyncline during the Middle Cambrian.
2. The magma, when erupted, was not soda rich. The association of greywackes, porphyries and keratophyres (developed from sedimentary and volcanic rocks) containing albite, points to a secondary origin for the albite.
3. Hydrothermal alteration is prevalent with albitization, silicification and chloritization indicating an enrichment in soda, silica and alumina. The mineral assemblage developed indicates low temperature conditions, although the formation of hydrogrossular and possibly hornblende indicate locally higher temperatures.
4. Silicification is revealed by the abundance of secondary quartz in the lavas, together with the formation of jasper and spherulitic quartz rock.
5. Soda and silica metasomatism of the lavas along a major geanticlinal structure has given rise to the formation of a variety of porphyries and possibly keratophyres.
6. The chemically active solutions which caused the hydrothermal alteration were activated by heat and movement during the Tyennan Orogeny (Late Cambrian) giving rise to metasomatism which affected the lavas. The Tabberabberan Orogeny (Middle Devonian) was responsible for further alteration of the " porphyroids " and possibly the development of the hydrogrossular on King Island and hornblende on the Tyndall Range.

7. The formation of the spilitic suite was from normal basic lavas and was due to the geosynclinal environment. It was activated primarily by heat and crustal movement.
8. The necessary supply of soda, silica and alumina came from a redistribution of the normal content of these constituents in the sediments of the geosyncline.

Acknowledgments

Thanks are extended to Mr. W. H. Williams, Director of Mines in Tasmania, for his kindness in allowing the author access to the many slides in the Mines Department; to Miss E. M. Smith, formerly Geological Indexer for the Bureau of Mineral Resources and now of Geology Department, University of Tasmania, for her help in making the geological index available, and to Mr. M. R. Banks of the Geology Department who was always willing to lend a helping hand and to discuss any problems which presented themselves. The author greatly appreciates the help and encouragement readily given by Professor Carey throughout the study and for his help in reading and checking the manuscript and seeing it through the press.

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LOCALITY INDEX

Locality	*Quadrangle*	*Latitude S*	*Longitude E*
Arthur River	Magnet 35	41° 28′	145° 27′
Balfour	Balfour 34	41° 16′	144° 55′
Beaconsfield	Beaconsfield 30	41° 11′	146° 45′
Beulah	Sheffield 37	41° 26′	146° 24′
Castray River	Corinna 43	41° 32′	145° 20′
Comstock	Lyell 58	42° 02′	145° 39′
Cradle Mt.	Mackintosh 44	41° 40′	145° 57′
Cressy	Longford 47	41° 40′	147° 08′
Dial Range	Devonport 29	41° 11′	146° 01′
Double Cove	Macquarie Hbr. 64	42° 20′	145° 20′
Duck Bay	Smithton 21	40° 50′	145° 04′
Dundas	Zeehan 50	41° 53′	145° 28′
Grassy River	S.E. King Island 1	40° 02′	144° 04′
Groom's Slip	Devonport 29	41° 07′	146° 06′
Heazlewood	Magnet 35	41° 30′	145° 18′
High Rocky Point	Mongomery 78	42° 46′	145° 23′
King Island	———	40° 00′	144° 00′
King River	Strahan 57	42° 10′	145° 30′
Lake Margaret	Murchison 51	42° 01′	145° 37′
Leven Gorge	Devonport 29	41° 15′	146° 10′
Lucy River	Corinna 43	41° 37′	145° 07′
Lynch Creek	Lyell 58	42° 07′	145° 33′
Mackintosh River	Mackintosh 44	41° 43′	145° 37′
Macquarie Harbour	Macquarie Hbr. 64	42° 15′	145° 25′
Magnet	Magnet 35	41° 28′	145° 26′
Mainwaring River	Rocky Point 79	42° 49′	145° 32′
Montana	Zeehan 50	41° 51′	145° 17′
Montezuma Falls	Zeehan 50	41° 51′	145° 27′
Mt. Chester	Mackintosh 44	41° 42′	145° 32′
Mt. Claude	Sheffield 37	41° 30′	146° 12′
Mt. Darwin	Lyell 58	42° 16′	145° 36′
Mt. Farrell	Mackintosh 44	41° 44′	145° 34′
Mt. Jukes	Lyell 58	42° 11′	145° 36′
Mt. Lyell	Lyell 58	42° 03′	145° 37′
Mt. Ramsay	Corinna 43	41° 36′	145° 27′
Mt. Read	Murchison 51	41° 53′	145° 33′
Murchison River	Murchison 51	41° 51′	145° 42′
Naracoopa	Sea Elephant 6	39° 54′	144° 06′
Penguin	Devonport 29	41° 07′	146° 06′
Port Davey	Davey 91	43° 20′	145° 55′
Quamby Brook	Quamby 46	41° 33′	146° 47′
Que River	Mackintosh 44	41° 36′	145° 31′
Queenstown	Lyell 58	42° 05′	145° 33′
Red Hills	Murchison 51	41° 00′	145° 33′
Rosebery	Murchison 51	41° 47′	145° 33′
Smithton	Smithton 21	40° 41′	145° 06′
Tullah	Mackintosh 44	41° 43′	145° 38′
Tyndall Range	Murchison 51	41° 56′	145° 38′
Wanderer River	Point Hibbs 71	42° 43′	145° 25′
Waratah	Valentines Peak 36	41° 26′	145° 31′
Zeehan	Zeehan 50	41° 53′	145° 21′

Plate I —This and the following plates illustrate the various stages in the development of the secondary spherules of quartz:

Figure 1.—Illustrates one of the first stages in the development of the spherules. The quartz is beginning to take on a feathery form. The bulk of the mineral grains in this figure is of quartz with a few altered feldspar laths and some chlorite.

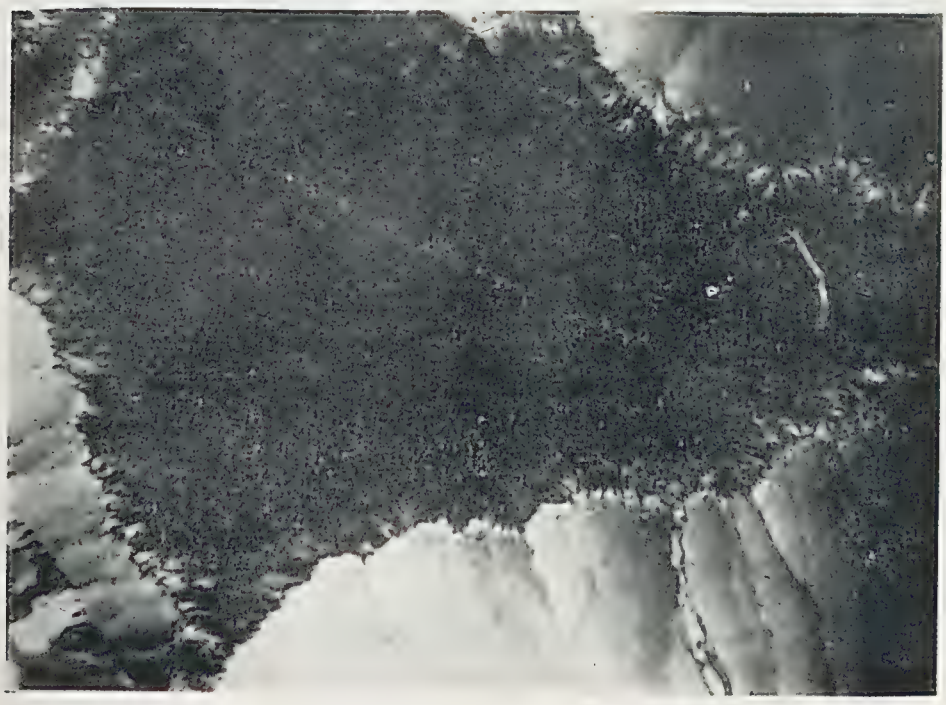

Figure 2.—The space between the spherules is filled with very fine granular quartz. Note the narrow radial fringe of quartz around the margins of the spherules.

Plate II

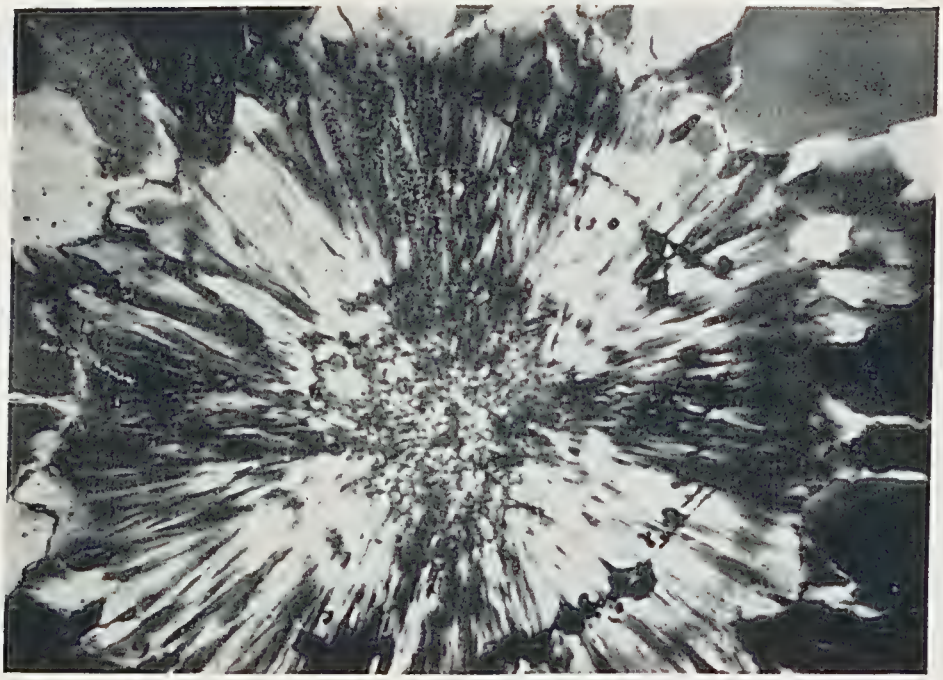

Figure 1.—Shows the development of the radial fringes of quartz (see figure 2) at the expense of the fine granular material, some of which is still to be seen in the centre of the newly developed spherule.

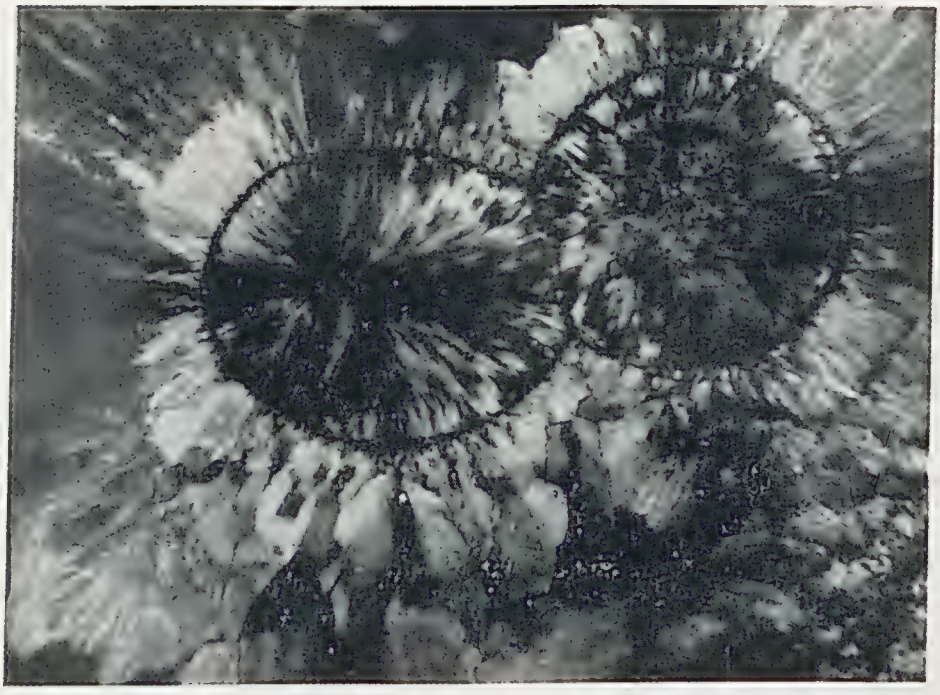

Figure 2.—In this case the fine grained material increased in grain size and at the same time the radiating fringes grew out. At the junction of the two a circular crack developed.

Plate III

Figure 1.—Illustrates the formation of two spherules which began to grow from the inside as well as the outside resulting in the formation of a crack where the two met.

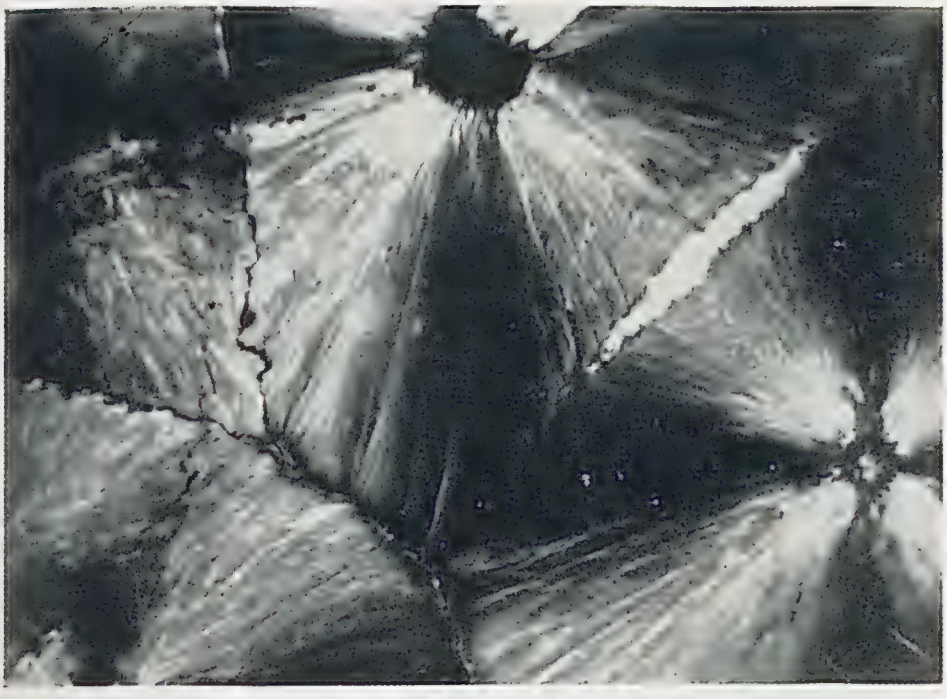

Figure 2.—Illustrates the final stage when the whole rock has been converted to a mass of spherules with very little or no granular material between them.

PLATE IV

FIGURE 1.—Idioblast of quartz in the hornblende andesite (?) showing the fine grained "replacement border" and inclusions of the groundmass.

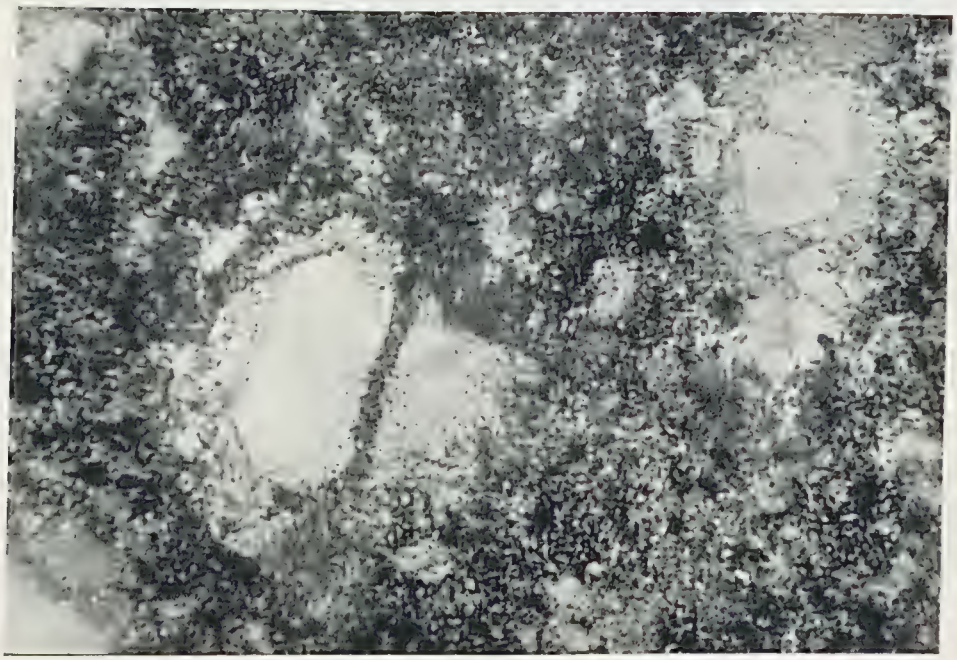

FIGURE 2.—Idioblasts of quartz growing out of patches of quartz in the groundmass of a porphyroid from Dundas.

Papers and Proceedings of the Royal Society of Tasmania, Volume 88

An Unconformity in South-West Tasmania

By

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(communicated by professor s. warren carey)

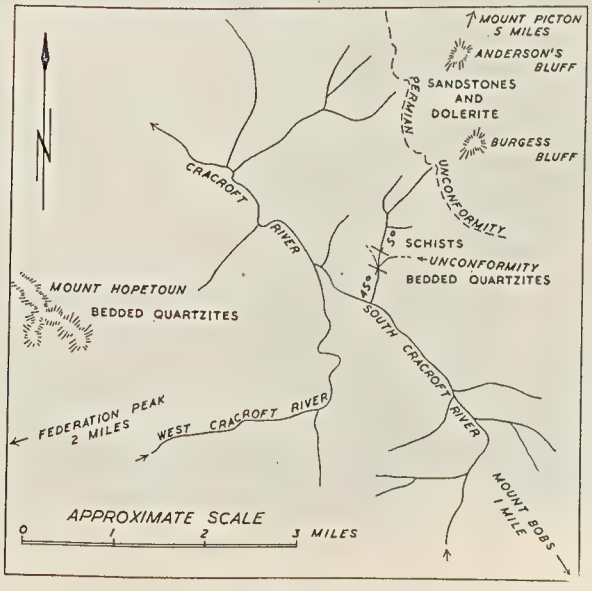
This note is intended to record an unconformity in the Federation Peak district of south-west Tasmania, which has not been previously reported.

The unconformity is well exposed in a small creek in burnt-out country at a point approximately 1000 yards east of the junction of the West and South Cracroft Rivers. The locality is included on aerial photographs Nos. 1673, 1674 of Run. 15, Picton.

The older formation has a prominent schistosity dipping to the N.N.E. at from 45° to 60°. Localised puckering of this schistosity is common and at some places another planar structure is evident. Rock types in this older formation include quartz schists, mica schists and sheared conglomerates.

The younger formation dips to the S.S.W. at 35°. It is composed of well-bedded white quartzites with occasional very thin conglomerates. Elsewhere, as on Mt. Hopetoun, this formation of well-bedded quartzites displays common current-bedding and ripple mark.

The unconformity is illustrated in the photograph (Plate I, Fig. 1), and its position is shown on the accompanying sketch map (text. fig. 1).



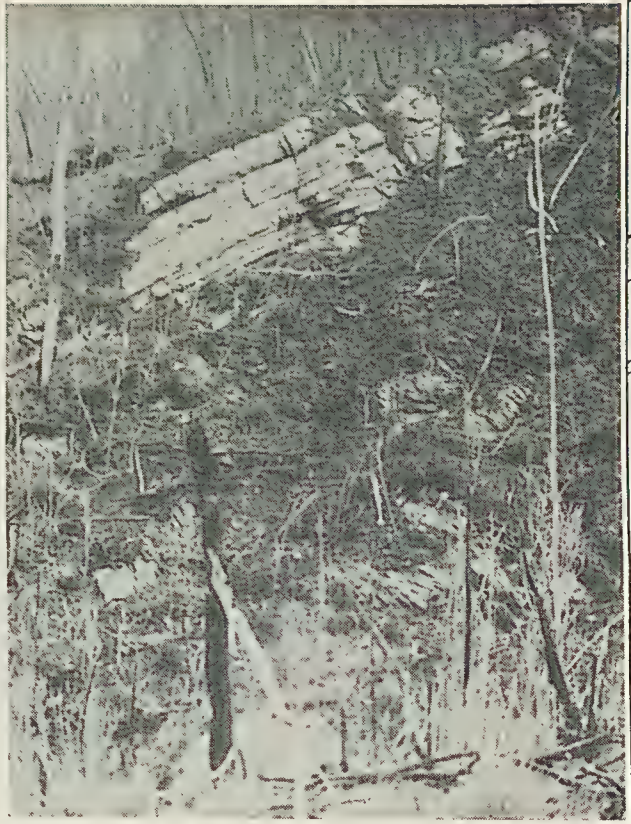


FIG. 1.—Photograph of unconformity between quartzites and conglomerates above and quartz and mica schists below, near the junction of the branches of the Cracroft River, S.W. Tasmania.

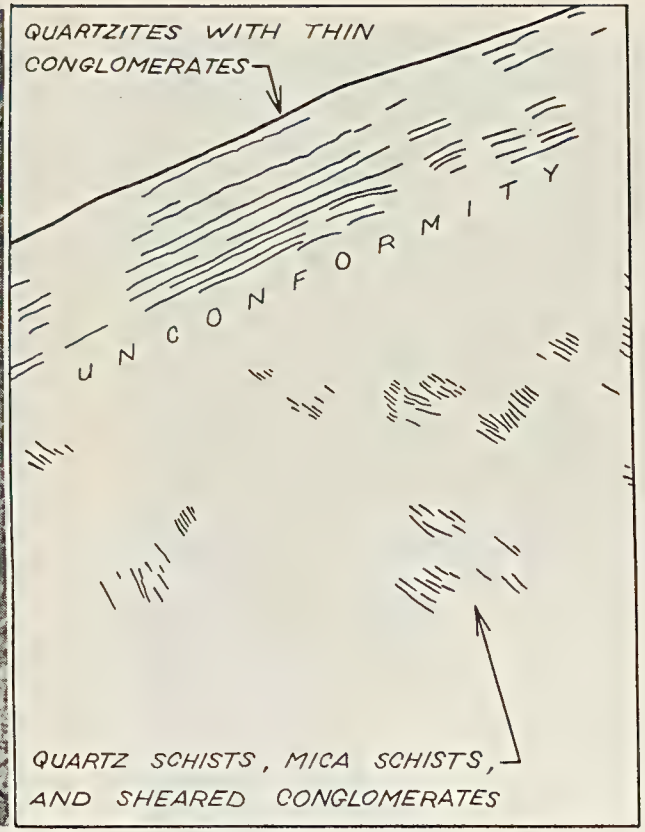


FIG. 2.—Tracing showing structures on Fig. 1.

The Geology of the Franklin-Glendevie Area

By

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Abstract

The Franklin-Glendevie area contains Permian and Triassic mudstones, sandstones and shales which have been extensively intruded by dolerite and broken by block faulting, some of which was related to the intrusions, and some much later. The sediments have a regional dip to the south-west and have been intruded by dolerite and syenite sheets and dykes, which have narrow contact margins of baked rock. The upper Permian rocks appear to be thinner than in the Hobart area.

Introduction

The boundaries of the area in which the investigation was carried out are defined by the co-ordinates 480,000 yards E. to 490,000 yards E. and 670,000 yards N. to 697,000 yards N. on sheet No. 6 of the four-mile State map of Tasmania. The purpose of the investigation was to map and study the geological structures and stratigraphy of this area.

Acknowledgments are due to Prof. S. W. Carey, under whose direction the field work was carried out.

Stratigraphy

Permian System

Granton Limestone

The lowest rocks in the Permian sequence in the area outcrop at Castle Forbes Bay. The base of the formation of which about 200 feet is exposed, cannot be seen and a dolerite intrusion obscures the top. The rock types present include dark-brown to blue porous mudstones and shales containing numerous muscovite flakes and indefinite brown spots, possibly representing decomposed pyrite nodules. Sandy laminated bands may also be present. Overlying these rocks are grey mudstones, containing a rich fauna of large *Eurydesma*, Spiriferids and *Platyschisma* interbedded with small bands of unfossiliferous mudstones with a characteristic curved fracture. *Fenestella* and other Bryozoa become more common in the higher horizons where the rock has even bedding and fine grains consisting of quartz, muscovite and feldspar fragments. This formation has been placed in the Granton Formation because it is lower in the sequence than the Grange Mudstone which occurs elsewhere. The typical Berriedale Limestone does not outcrop but is known on the opposite bank of the Huon at Glazier's Bay. It therefore appears that the limestone facies is thinning towards the south-west.

Grange Mudstone

The Grange Mudstone outcrops at Surges Bay, Geeveston, Doody's Hill and South Franklin. The base of the formation is not visible because of dolerite intrusions. Typically the rock consists of massive, hard, creamy-white fine-grained siliceous mudstones showing rhythmic bedding. The mudstones contain abundant erratics of quartz, albite, chert, and quartzite. These are embedded in a finer grained groundmass of quartz fragments less than 0·1 mm. in diameter. The diameters of the erratics, which may be either water-worn or angular, vary from 2 mm. to 100 mm. There are coarser bands similar to the Risdon Sandstone, but these are more silicified and do not weather to the sand characteristic of the Risdon. Efflorescences of epsomite occur where water seeps to the surface on steep faces such as in the road quarry at Waterloo. On Doody's Hill and at South Franklin the lowest part of the Grange Mudstone outcrops as a fine-grained block-jointed shale, containing occasional erratics of granite, quartzite, quartz schist, and conglomerate up to one mm. in diameter, with peculiar dark spots formed by the segregation of chlorite, sericite and limonite. Where observed, the spotted shale occurs in contact with dolerite which may have caused the spotting by development of chlorite in the groundmass through normal low-grade thermal metamorphism.

Richly fossiliferous bands are common in the Grange Mudstone although fossils may be absent in certain parts of the sequence. *Fenestella* and other Bryozoa may be so plentiful as to give a laminated appearance to the rock, as in the quarry at Waterloo. Brachiopods, pelecypods, and coiled gastropods are also common. Large pectinaceans, long-spined productids, moulds of large spiriferids, *Platyschisma,* and *Eurydesma* occur together with other fossils. The maximum thickness of the Grange Mudstone appears to be about 400 feet as exposed on Doody's Hill.

Woodbridge Glacial Formation

This formation, lying conformably between the Grange Mudstone and the Risdon Sandstone has a maximum thickness of about 100 feet. Lying above the Grange Mudstone at the Waterloo Quarry, the Woodbridge Glacial Formation is largely a friable, porous, and highly iron-stained sandy mudstone. Associated with it is a ferruginous material with a gossanous outcrop consisting of limonite and haematite and vitreous hydrated iron minerals. This may have been formed by leaching and concentration of iron in parts of the rock. The unaltered rock consists of fragments of clear and cloudy quartz with an average size of approximately 0·5 mm. Larger angular erratics of clear and cloudy quartz up to 3 mm. in diameter, are present. Fossils are absent.

At Geeveston the rock is a white iron-stained sandy mudstone, much finer grained than that at Waterloo. The basal tillite is missing but some coarse conglomerate phases exist near the top of the Grange Mudstone.

Ferntree Mudstone

This formation conformably overlies the Woodbridge rocks. The basal member is the Risdon Sandstone, a distinctive marker, which is very useful in the field. This sandstone is massive, current-bedded and resistant to weathering and outcrops in cliffs or steep slopes. The Risdon varies from a fine-grained to coarse-grained siliceous sandstone containing about 30 per cent feldspar and occasional rounded quartzite boulders, and other erratics up to six inches in diameter. The composition of these does not vary as much as in the Grange Mudstone. The grains of the rock consist mainly of cloudy sub-angular quartz which forms a coarse sand as the rock weathers. The Risdon Sandstone is generally a uniform type; however, near the old Geeveston cemetery the rock is interbedded with a shaly laminated sandstone which is much finer in grainsize than usual and which contains numerous small ironstone concretions. At the Surges Bay clay pit the siliceous sandstone phase has developed an intense green-blue stain. The Risdon Sandstone varies from 10 to 20 feet thick and also outcrops above the Woodbridge Formation at Cairns Bay, Franklin, and the Kermandie River.

Typical Ferntree Mudstone follows the Risdon Sandstone. It is composed of rhythmically bedded, dense, fine-grained, porous, grey to dark-blue mudstones, weathering to white or buff coloured rocks, and contains narrow bands of interbedded shales up to three feet thick. Concretionary structures are common and the higher members of the formation have characteristic dark carbonaceous markings and other organic remains. Microscopically the mudstone contains angular grains of clear quartz and occasional feldspar fragments ranging in size from 0·05 mm. to 0·1 mm. in diameter. Sometimes the rock may be cemented by a ferruginous cement which may make up 50 per cent of the rock. Erratics are not very common. When present they consist of angular dark and clear quartz, granite, quartzite, and mica schist, their size rarely being greater than 3 mm. in diameter although larger dropped pebbles can be found. Animal fossils have not been found but fossil wood occurs in the Bird's Hill quarry. The total thickness of the Ferntree Mudstone as measured from the base of the Risdon Sandstone to the base of the Triassic system on Bird's Hill, is about 300 feet. The typical Ferntree Mudstone outcrops at Franklin, Geeveston, Bird's Hill, Surges Bay, Dover Rivulet and the Esperance River. On the coast south of Killala Bay the Ferntree Mudstone forms small stacks where it overlies intrusions of syenite.

Cygnet Coal Measures

The Cygnet Coal Measures do not outcrop in the area, but on the Esperance River where the basal part of the Triassic System overlies the Ferntree Mudstone, a coarse, loosely consolidated, yellow, laminated, ferruginous sandstone showing slump structures may be the equivalent horizon.

TRIASSIC SYSTEM

Knocklofty Sandstone and Shale

This is the base of the Triassic System which disconformably overlies the Ferntree Mudstone. The formation consists of massive, strongly cross-bedded, well sorted, even grained, quartzose sandstones containing clay pellets and some siderite concretions, together with interbedded bands of friable laminated shales which often pass laterally into sandstone beds. The shales are coloured grey, brown, green and orange, and frequently contain muscovite and graphite on the bedding planes. Microscopically, the Knocklofty Sandstone consists of rounded to sub-rounded clear and cloudy quartz grains from 0·1 to 0·2 mm. in diameter occasionally showing regrowth, with a matrix of sericitic material and often a ferruginous cement. The rock weathers to a uniform quartz sand. No fossils have been identified but carbonaceous remains occur in some of the higher shales. The greatest thickness of this formation is exposed along the Hopetoun Road where about 600 feet outcrops. The sandstone forms steep slopes at Dover, Glendevie, Surges Bay, and Waterloo.

Feldspathic Sandstone

This formation is the highest Triassic formation in the area and outcrops east of Glendevie. The rock consists of massive iron-stained sandstones of extremely uniform grain-size representing a very well-sorted sediment. The grains, which consist of quartzite, mica, schist, sericitic material, cloudy quartz, acid plagioclase, orthoclase, and microcline, are about 0·2 mm. in diameter, embedded in an indeterminate groundmass which is heavily stained by a ferruginous cement. The feldspar is easily leached to give a porous siliceous rock similar to leached Knocklofty Sandstone. Overlying the typical sandstone is 50 feet of a dense, dark, carbonaceous shale with a rounded fracture and well developed muscovite flakes on the bedding planes. The total exposed thickness of the formation is about 200 feet.

QUATERNARY SYSTEM

A Pleistocene or Recent deposit occurs on the Esperance River where it forms an unconsolidated mass of dolerite and sandstone boulders about 10 feet thick overlying the Ferntree Mudstone. Along Crooks Rivulet a similar deposit has been consolidated to a conglomerate about 5 feet thick.

Terrace gravels occur along the bank of the Huon River at Franklin and Castle Forbes Bay reaching a maximum height of about 100 feet above the river at Franklin. At Castle Forbes Bay well sorted interstratified gravels and sands are about 50 feet thick.

IGNEOUS ROCKS

Dolerite

The area has been intruded by dolerite in irregular bodies which appear to be dyke-like or sill-like and also as transgressive sheets. The highest Triassic rocks have been intruded by the dolerite, hence the intrusions are post-Triassic in age in this area. The rock is uniformly

fine to medium-grained, and contains 35 per cent of augite and plagioclase of approximate composition Ab_{45} An_{55}. Dolerite is the most common rock in the area. The thickness of the intrusions seems to vary from 100 feet on the top of Doody's Hill to 1,400 feet on the hills west of Franklin. The contact effects of the intrusions are confined to baking of the sediments and chilling of the dolerite on the margins. At Surges Bay, chalcedony has developed on the contact with the Grange Mudstone. Occasional calcareous fossils in the Grange Mudstone at Doody's Hill have reacted with the surrounding material under the influence of the heat of intrusion to form small reaction centres containing prehnite, tremolite, anorthite and biotite.

Syenite

The syenite occurs in a series of small dykes and sills intruded into the Ferntree Mudstone south of Surges Bay. The rock is part of the Cygnet intrusion which lies to the east on the opposite bank of the Huon River. The rock is usually deeply weathered to kaolinite containing relatively unweathered phenocrysts of orthoclase. The unweathered rock is a light-grey, hard, dense porphyritic rock containing abundant large phenocrysts of feldspar, about 2 cm. in diameter, embedded in a grey groundmass containing small crystals of ferro-magnesian minerals. The main minerals present are augite (10 per cent) fresh hornblende (10 per cent), plagioclase (Ab_{90} An_{10}—50 per cent) and orthoclase. Accessory minerals include magnetite, sphene, and apatite. The groundmass constitutes 25 per cent of the rock and consists of minute grains of feldspars, ferro-magnesian minerals, and magnetite. The contact effects of the syenite with the country rock are confined to slight baking of the margins with no evidence of contamination or assimilation. The variation of grain size in the syenite at the contact is not as marked as in dolerite on similar contacts. The syenite appears to have a porphyritic texture right to the edge of the intrusion.

STRUCTURAL GEOLOGY

The structure of the area is controlled by the occurrence of the dolerite intrusions and by faulting, both pre-dolerite and post-dolerite in age. In the Franklin area the major rock type is dolerite which exists as a large transgressive sheet with the underlying rocks showing through "windows" in the dolerite. This sheet is associated with concomitant faulting at Franklin where the sediments have been displaced, but intrusive contacts are present along the line of the faults. Five miles west of Franklin the Ferntree Mudstone outcrops from beneath the dolerite. The position of the Ferntree Mudstone shows that faulting concomitant with the intrusion has taken place. At Castle Forbes Bay the sheet of dolerite appears sill-like over the Granton Formation, with a low dip to the north-east. The intrusion here appears to dip beneath the Grange Mudstone at South Franklin.

In the Geeveston area the dolerite appears to be intruded into the Grange Mudstone as two sills on Doody's Hill. The sills are part of the same intrusive sheet. The bottom dolerite intrudes the Grange Mudstone south of Doody's Hill and becomes transgressive across the Woodbridge

Glacial Formation and Ferntree Mudstone to the north and finally merges with the dolerite of the top sill. The summit of Doody's Hill is an outlier of the top dolerite sill. On the Kermandie River at Geeveston the transgressive nature of the dolerite contact can be seen. West of Geeveston the dolerite appears on the banks of Crooks Rivulet as a sill-like intrusion, dipping at a low angle to the west. On the Kermandie River the intrusion appears as a sill combined with a concomitant strike fault or as a flat sheet trangressing the Ferntree Mudstone.

The discordant sill shown on the map immediately south-west of Geeveston is transgressive over the Ferntree and Woodbridge Formations. An area of baked mudstone and siliceous hornfels exists between this sill and the larger one on the hill-top. The dolerite immediately south of Geeveston is dyke-like and was apparently the feeder channel between two major sedimentary blocks. South of this channel, the Triassic sandstones and shales outcrop, overlying the Ferntree Mudstone. However, north of this the Triassic sandstones do not outcrop until the extreme north-west of the area is reached. The Knocklofty Sandstone and the Ferntree Mudstone are approximately on the same level and have the same strike, so that the block on the southern edge of the dolerite is downthrown with respect to the northern block. The dolerite becomes sill-like in form, west of Cairns Bay where the Permian sediments have been intruded. On the western boundary the dolerite transgresses the Knocklofty Sandstone to form a sill capping the hills. On the coast at Waterloo the outcrop of the dolerite suggests that it occurs at the edge of a sill or a dipping dyke. The small cove, developed at Flights Bay, cuts through the dolerite into the Permian rocks. North of Flights Bay the apparent sill beneath the Ferntree Mudstone and Grange Mudstone may only represent a transgressive contact, the Grange Mudstone being present beneath the dolerite. In the Glendevie area the distribution of the dolerite is relatively simple. Storm Hill, Tongatabu and the hill two and a half miles west of Tongatabu, consist of sills of dolerite capping the Knocklofty Sandstone. Where Riley Creek cuts the northernmost dolerite of the Glendevie sheet, the intrusion is dyke-like and appears to be the feeder for the other sills. Small dykes intrude the Waterloo and Wobbly Creek areas.

Prominent pre-dolerite faults occur at Franklin, Castle Forbes Bay, and one and a half miles south of Geeveston. At Castle Forbes Bay on the southern side of the Valley, typical Grange Mudstone is found, while the Granton Formation outcrops on the northern side. From a consideration of dips and the fact that the intrusive dolerite boundary is not broken, the fault is identified as pre-dolerite intrusion in age. South of Geeveston the dolerite is intruded beneath a block of sediments in which the Grange Mudstone has been faulted against the Ferntree Mudstone. The fault can be seen on the Huon Highway. It is pre-dolerite because the intrusive boundary is not displaced and there is no fault joint pattern in the dolerite.

Post-dolerite faults, which displace the intrusive boundaries, cut the south end of Tongatabu. The Glendevie fault is considered post-dolerite because no intrusive contacts can be seen along its length. The age of the fault through Surges Bay cannot be proved as the Ferntree

Mudstone has been downthrown relative to other lower Permian formations, and no intrusive boundaries are present to show their relation to the fault. The dolerite on the northern side of Flights Bay has been highly sheared and it is probable that this has been caused by a fault running east-west.

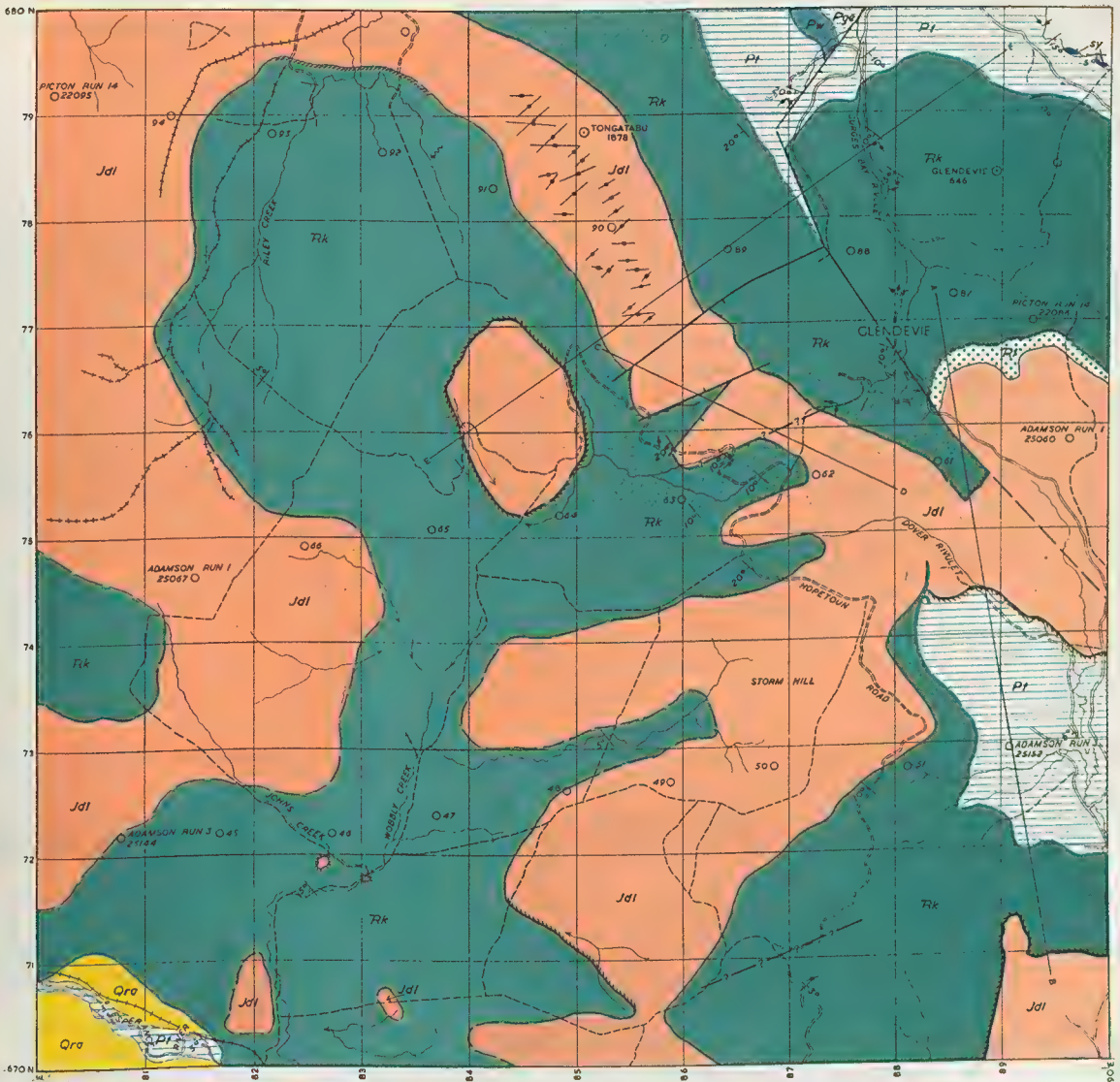
LOCALITY INDEX

	Internat. Grid Reference K/55	S. Lat.	E. Long.
Bird's Hill	Picton 87	43° 12′	146° 57′
Cairns Bay	Picton 87	43° 11′	146° 58′
Castle Forbes Bay	Picton 87	43° 08′	146° 59′
Castle Forbes Bay Rivulet	Picton 87	43° 07′	146° 57′
Crooks Rivulet	Picton 87	43° 09′	146° 54′
Doody's Hill	Picton 87	43° 09′	146° 56′
Dover	Dover 94	43° 19′	147° 01′
Dover Rivulet	Dover 94	43° 17′	147° 01′
Egg Islands	Kingborough 88	43° 04′	147° 04′
Esperance River	Adamson 93	43° 18′	146° 54′
Fleurty's Rivulet	Picton 87	43° 06′	146° 56′
Flights Bay	Picton 87	43° 12′	146° 58′
Franklin	Kingborough 88	43° 05′	147° 01′
Geeveston	Picton 87	43° 11′	146° 57′
Glendevie	Picton 87	43° 14′	146° 59′
Kermandie River	Picton 87	43° 10′	146° 54′
Killala Bay	Picton 87	43° 13′	147° 00′
Port Huon	Picton 87	43° 09′	146° 58′
Riley Creek	Picton 87	43° 13′	146° 56′
Scott Rivulet	Picton 87	43° 08′	146° 55′
South Franklin	Picton 87	43° 07′	147° 00′
Surges Bay	Picton 87	43° 13′	147° 00′
Tongatabu	Picton 87	43° 14′	146° 57′
Waterloo	Picton 87	43° 12′	146° 58′

GEOLOGY OF TASMANIA
ONE INCH SERIES — UNIVERSITY OF TASMANIA, GEOLOGY DEPARTMENT.

GLENDEVIE

48-67



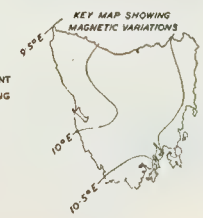
- FAULT WITH DOWNTHROW SIDE INDICATED
- FAULT - POSITION APPROXIMATE
- FAULT INFERRED
- FORMATION BOUNDARY
- DOLERITE BOUNDARIES
- CONCORDANT SILL
- DISCORDANT INTRUSIVE BOUNDARIES
- DISCORDANT INTRUSIVE BOUNDARIES WITH CONCOMITANT FAULTING
- VERTICAL JOINTS
- STRIKE AND DIP
- ROADS
- VEHICULAR TRACK
- TRACK
- TRAMWAY
- DISUSED TRAMWAY
- HORIZONTAL CONTROL STATION

— SCALE —

0 2 MILES

0 1 2 3 4 5,000 10,000 FEET

KEY MAP SHOWING MAGNETIC VARIATIONS



Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Lands and Surveys Dept. Origin of co-ordinates 400,000 yds West and 1,800,000 yds. South of True Origin of Zone 7.

MAPPED AND COMPILED BY R J FORD JANUARY 1952

Quaternary System
RECENT SERIES
- Qra ALLUVIUM

Triassic System
- Trp FELSPATHIC SANDSTONE
- Trk KNOCKLOFTY SANDSTONE AND SHALE

Permian System
- Pt FERNTREE MUDSTONE
- Pw WOODBRIDGE GLACIAL FORMATION
- Pge GRANGE MUDSTONE

Jurassic System
- Jdl DOLERITE

SYENITE PORPHYRY

GEOLOGY OF TASMANIA

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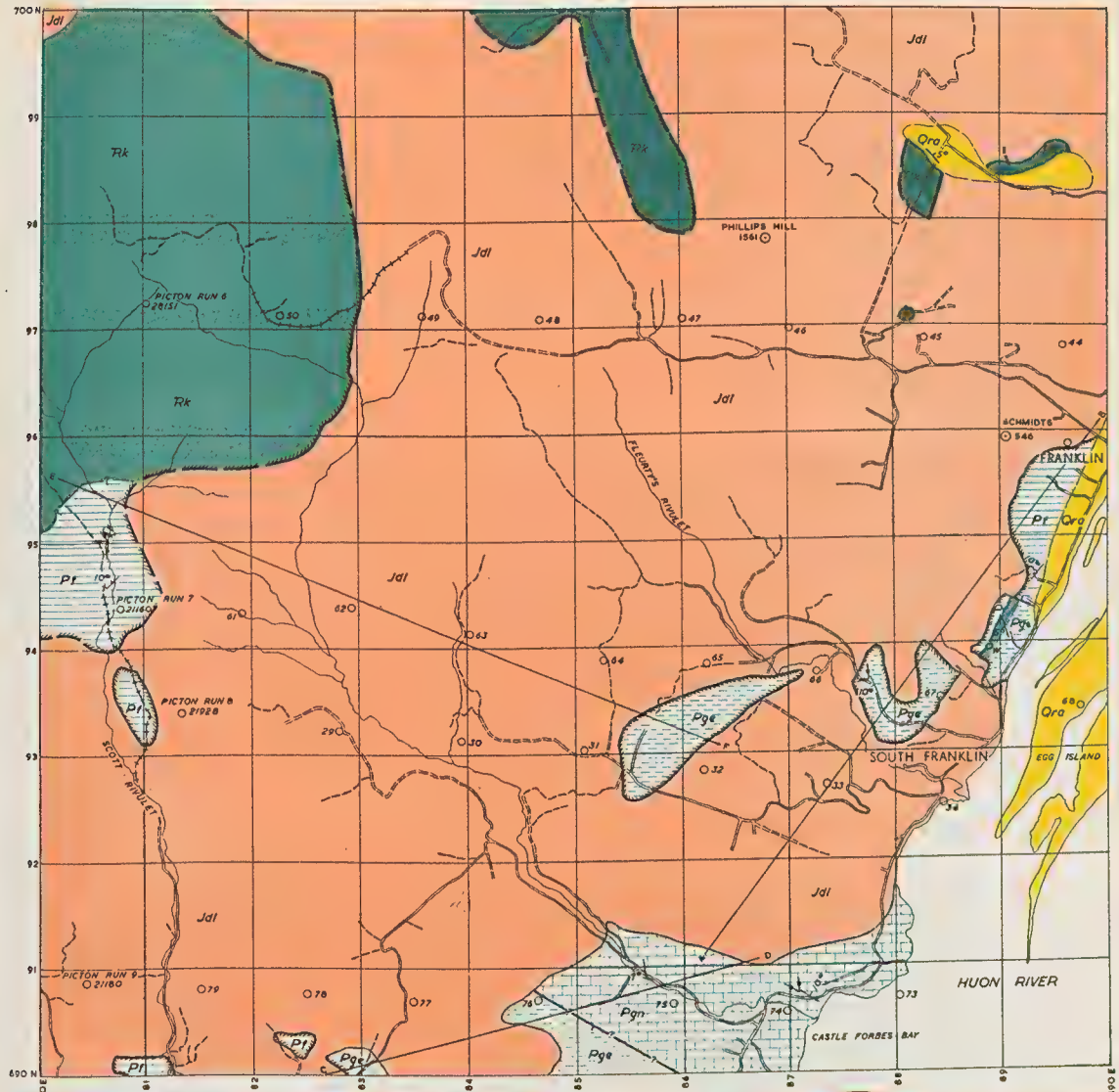
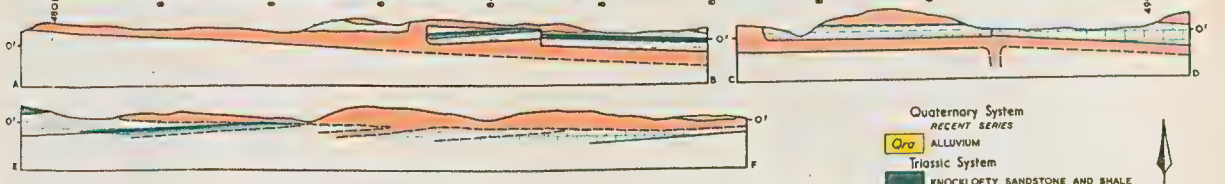
FRANKLIN

48-69





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- HORIZONTAL CONTROL STATION

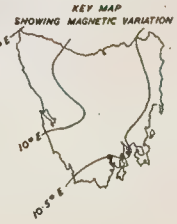
— SCALE —

2 MILES

0 1 2 3 4 5,000

10,000 FEET

KEY MAP
SHOWING MAGNETIC VARIATION



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MAPPED AND COMPILED BY
R J FORD AND R P MATHER
JANUARY 1952

Quaternary System
RECENT SERIES
- Qra ALLUVIUM

Triassic System
- KNOCKLOFTY SANDSTONE AND SHALE

Permian System
- Pf FERNTREE MUDSTONE
- Pw WOODBRIDGE GLACIAL FORMATION
- Pgg GRANGE MUDSTONE
- Pgs GRANTON LIMESTONE

Jurassic System
- Jdl DOLERITE

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Papers and Proceedings of the Royal Society of Tasmania, Volume 88

Geology of the Dundas District, Tasmania

By

John Elliston
(*Department of Mines, Hobart*)

Abstract

Precambrian schists of the Davey Group are overlain by conglomerates, dolomite, black slates and quartzites of the Carbine Group, which is defined. Unconformably overlying the Carbine Group are 10,000 feet of conglomerate, tuff, breccia, and lava flows alternating with slates which contain Middle Cambrian fossils, defined here as the Dundas Group. The alternation of conglomeratic and finer sediments should persist throughout the Cambrian sedimentary basin and facilitate correlation. The Dundas Group is intruded by serpentine, which is probably of Upper Cambrian age; the Gordon Limestone of Ordovician age transgresses over, or is faulted against, the Dundas Group. Almost horizontal Permian sediments rest on an eroded surface of the Cambrian and Precambrian rocks and have been intruded by a sill of dolerite along the unconformity and another at a higher level.

The main structure of the Precambrian and Lower Palaeozoic rocks in the Dundas area is a dome pitching to north-east and south-west which is associated with other folds trending in the same direction, and cross-folds. Overthrust faulting with horizontal movement cuts the folds.

Introduction

Acknowledgments

This paper presents part of a thesis submitted for the degree of Bachelor of Science with Honours in the University of Tasmania.

Initially the regional survey of the Dundas field was an undertaking of the North Broken Hill Company's Exploration Branch by whom the writer was employed. The initial work in surveying the central Dundas area was done under the direction of Mr. B. P. Webb assisted by Mr. B. G. May and the writer, under the general guidance of Professor S. W. Carey. Mr. P. B. Andrews also assisted with geochemical work and some field mapping. The work on the central Dundas area was done in the summer of 1949-50 and succeeded in establishing the general structure of the Dundas anticlinal high. From this point the work was carried forward by the writer alone although still employed by the company for some time and assisted throughout by the guidance of Professor S. W. Carey.

A stratigraphic sequence was established below the limestone near Mount Misery and several fossil localities were found which have helped to elucidate this Cambrian succession. These fossil localities have been visited by Dr. A. A. Opik of the Commonwealth Bureau of Mineral Resources who has given the determinations recorded in this paper.

Geography

Dundas occupies an erosional basin carved in the deeply serrated western flanks of Mount Dundas (3,980 feet) by the Dundas Rivulet drainage system. Continuous plateau and spur country extends northwards from Mount Dundas to Moore's Pimple with highlands of the Goodkin Ridge and Carbine Hill forming an east-west branch arm of the dissected plateau. This high country separates the northern Ring River Valley from the central Dundas area. In the south-west of the area two strike ridges of hard conglomerate, Mount Misery and Mount Razorback, stand well above the softer slates and pyroclastics forming the undulating country between them. Connecting the dividing central arm of the plateau with the hills to the north-west is the Confidence Saddle which links the upstanding massive serpentine of Pine Hill and Commonwealth Hill to the Carbine Hill chain.

From Moore's Pimple radiate three major drainage systems. The Henty catchment to the south-east drains the eastern side of Mount Dundas, the north and west flowing streams reach the Pieman River, while the Dundas Rivulet system originating on the steep western flanks of Mount Dundas flows out across the Zeehan plains as part of the Little Henty River catchment. The erosion rate is rapid and the streams rise and fall rapidly when the ground is saturated. The Dundas tuffs and slates weather to a yellow clay which, when saturated and lubricated by the heavy rainfall, slides, complete with vegetation cover, down the steep rock slopes into the creeks. There are many of these landslides in the area and they often succeed in damming the creeks for a year or two. The topography of the area is young. Deep valleys, steep slopes, sharp ridges, gorges and cliffs are found throughout.

The thick coverage of different types of vegetation over the entire area is so much an obstruction and hindrance to the geologist that some knowledge of its habits is necessary to avoid undue delay in moving through the area. With the exception of the button-grass on the high land and Melba Flat the whole area is covered with dense rain forest and vigorous secondary regrowth. Wherever the tall trees of the myrtle forests or the well grown ti-tree and blackwood stands shut out the light the forest floor is comparatively free from undergrowth and this facilitates traversing. However, the forest fringes, the more sparsely forested high country, and the regrowth areas are almost impenetrable because of the dense mat of tangled undergrowth.

The stream beds provide the only good rock outcrop. Their deep cut valleys in the steep hillsides expose the bedrock almost continuously. The rough stream beds are difficult to traverse but the most valuable information is obtained in this way. Rail cuttings on the disused Zeehan-Dundas railway and the North-East Dundas tram reveal easily mappable exposures, but even in conjunction with stream traverses insufficient data can be gained from this source to determine completely the structure of this closely folded region. Many parts of the area are accessible by timber tracks which, although often more or less overgrown, provide geological information, since their deep gougings have exposed the bedrock. There are occasional outcrops on the sharp spurs but the steep hillsides are covered with scree and vegetation.

Dundas has a cool humid climate. The high rainfall varies markedly with altitude, but actual records for Dundas have not been kept. Zeehan, about five miles to the west, has an average of 98 inches while Mount Read, about three miles to the east of Dundas, records 136 inches. Snow covers the eastern highlands for long periods in winter but by contrast to the incessant winter rains, very hot days and dry periods are often experienced in January, February and March when the streams dwindle rapidly to mere trickles.

Stratigraphy

Summary of Stratigraphic Succession:

	Thickness
PERMIAN SYSTEM.	
Siluro-Devonian:	
ELDON GROUP—	
Ordovician:	
JUNEE GROUP—	
Gordon Limestone	
Cambrian:	
DUNDAS GROUP—	
Misery Conglomerate	500
Climie Slate and Tuff	2,000
Fernflow Conglomerate and Tuff	470
Comet Slate and Tuff	1,050
Fernfields Tuff and Conglomerate	1,950
Brewery Junction Slate and Tuff	2,450
Curtin Davis Volcanics	1,000
Razorback Conglomerate	225
Hodge Slate	530
Red Lead Conglomerate and Tuff	250
Severn Slate	800
South Comet Grit	150
Judith Slate and Tuff	200
Total for Dundas Group	11,575 feet
Precambrian:	
CARBINE GROUP—	
Higgins Slate and Quartzite Platt Dolomite Maestries Dolomitic Conglomerate	approx. 2,000 feet
DAVEY GROUP—	
Older schists, phyllites and quartzites.	

Davey Group.

The term Davey Group has been assigned by Hills & Carey (1949) to the basal Tasmanian sedimentary rocks of Precambrian age. The exposure at Dundas is on the western flank of Mount Dundas, extending northwards from Comet Creek to Concert Creek.

Originally a group of dominant sandstones with grits and shales, they have undergone low grade dynamic metamorphism to form quartzites and schists. The schistosity strikes S. 60° E. consistently.

The original shaly facies are crenulate mica schists, argillaceous schists and quartz sericite schists. They are strongly crumpled and deformed and for the most part bedding is indiscernable. It is visible in certain localities only where a contact between the various types of schist indicates change in initial lithology. It will be very difficult to subdivide this group.

Carbine Group

The Carbine Group is defined as that group of formations overlying the Davey Group and unconformably overlain by the Dundas Group. The type section is exposed along the Dundas Rivulet from the serpentine boundary a quarter of a mile downstream from Maestries Station to the boundary with schists of the Davey Group about three-quarters of a mile upstream. No fossils have yet been found and the age of the group is considered as late Precambrian extending possibly into the Lower Cambrian. In the type section the group is about 2,000 feet thick and consists of the Maestries Dolomitic Conglomerate, the Platt Dolomite and the Higgins Slate and Quartzite. This group was referred to by Reid (1925) as the Bischoff Series. The name is derived from Carbine Hill. The lower contact may be an unconformity. The group outcrops around the Precambrian anticlinal core in the Dundas area, although to the east the group is thinned or missing where it has been faulted out by a large north-south overthrust with its downthrow to the east. The group also occurs in the Renison Bell area and in the lower Concliffe Creek Valley. The names Higgins Slate and Quartzite, Platt Dolomite and Maestries Dolomitic Conglomerate are used to designate the rock types within the group, and although an order is suggested it is not claimed to be established. Determination of the succession is important, though difficult, as many locally important ore deposits are in this group.

The Higgins Slate and Quartzite is the uppermost formation and is a succession of black slates and quartzites. The name is derived from Higgins Prospect. The black slates are rolled, contorted and puckered while the harder grey micaceous quartzites occur as thinner, sharply folded beds in the slates.

The Platt Dolomite occurs in the bed of Comet Creek just east of the Platt prospect, some 300-400 feet upstream from the bridge on the South Comet road. Although the outcrop is small the bed is fairly thick, since in testing the nearby Comet ore body a North Broken Hill bore-hole went through some 70-80 feet of the massive bedded dolomite. It is white to dark-grey in colour, often resembling marble. One of the best exposures is on Judith Creek, where a large massive outcrop forming the lip of a waterfall is penetrated for 30 feet by an adit. It contains occasional crystals of galena, specks of pyrite and quartz, and is riddled with calcite veins.

It is suggested that the underlying Maestries Dolomitic Conglomerate is basal in the Carbine Group. It has rounded quartz pebbles, up to two inches in diameter, in a finer silicified or dolomitised matrix. One of the occurrences of this conglomerate has been called a tillite, but it is not clear if all occurrences are correctly correlated or correctly regarded as tillite.

The whole Carbine Group is mineralised. The slates and quartzites near the Comet Mine are extensively injected with quartz veins, some of which are quite wide, while the black slates are pyritic. The Maestries Dolomitic Conglomerate is mineralised with pyrite and galena in small veinlets and sparse crystals. While the whole matrix is more or less dolomitised, there are also wide veins of injected carbonates which occasionally include siderite in addition to magnesite and calcite. This kind of mineralisation is general, but the ore bodies commonly contain pyrite, manganosiderite, dolomite, sphalerite, galena, jamesonite, arsenopyrite and the secondary minerals derived from them. None of the ore bodies in the Carbine Group worked so far has been very large.

Dundas Group

The Dundas Group is defined as the group of formations exposed in the section along the Dundas Rivulet between the serpentine contact north of the Razorback and Mount Misery, together with those exposed on Spur Track II from a point 800 feet beyond its recrossing of the Dundas Rivulet to the tributary of White Spur Creek. In the latter section the thickness exposed is 1,300 feet while 8,500 feet are exposed in the former; however, the Razorback-Misery section may be cut off at the top by a fault, so that the section may not represent the whole of the Cambrian sedimentation, which probably continues higher. The Dundas Group rests on the Carbine Group with an unconformity and in the type section is overlain by, or faulted against, Gordon Limestone of the Junee Group.

The group consists of tuffs, breccias, lavas, conglomerates and slates. Tuff beds occur on all horizons from bottom to top of the succession and reflect periods of volcanic resurgence. A cycle of volcanic activity, in which tuffs, water-sorted pyroclastics, lavas, volcanic bombs and ejectamenta were poured into the sedimentary basin, and normal sedimentation as the volcanoes subsided, is characteristic. The long periods of normal sedimentation are represented by thick slate formations with numerous tuff layers and an occasional breccia to indicate that the vulcanism still persisted though relatively quiescent.

No horizon can be traced reliably on lithology alone. The breccias, conglomerates and tuffs occur almost invariably as lenses and the slate thicknesses increase and decrease rapidly. However, alternating rock types have been divided into stratigraphic units, mapped, and named. It is probable that the lithology of the type section will only occur in areas having a similar relation to the centres of vulcanism or the axis of the volcanic belt, but it is hoped that the alternation between volcanic activity and quiescence will be recognisable in the Cambrian sediments throughout Tasmania.

With one exception the breccias and conglomerates of the type section are similar in lithology. This horizon was used as a marker. Despite its lensing, the distinctive lithology of the marker bed and the fossiliferous slates which occur immediately below enabled this horizon to be traced and the complex structure and the stratigraphic relationship of the beds to be successfully determined.

With the exception of the conglomerate on Mount Misery and the Razorback Conglomerate, the beds of the Dundas Group are soft and do not form outstanding outcrops. All members, including the black slates and grey grits, are usually covered with a weathering mantle of yellow soil or clay except where they are exposed by streams, railway cuttings, or tracks.

Both the Fernflow and Fernfields Volcanics contain thick purple slates and fine tuff beds with large sparse siliceous pebbles. It has been suggested that these dropped pebble beds are glacial but no striated boulders have as yet been found at this locality. The glacial origin is most likely, but alternatively there is the possibility of mud flows from steep volcanic slopes picking up the large boulders or a special type of stream erosion where the coarser material is deposited on a sandy stream bed and later covered by additional fine material. In the geological museum at the University of Adelaide, South Australia, is a glacial striated boulder recorded as having been collected by G. A. Waller near the Montezuma Falls and forwarded by him to Professor Howchin. Waller's precise locality is not known but some coarse irregular conglomerate lenses near Montezuma Falls resemble the Zeehan Tillite and the Red Lead Conglomerate high up the South Comet Creek. No more striated pebbles were found and the beds are thought to be stratigraphically equivalent to the Razorback Conglomerate. There is some evidence, then, of glacial activity concurrent with the vulcanism and extending at least well into the Middle Cambrian.

The succession in the Dundas Group is clearly established in the type section from the Misery Conglomerate down to the fossiliferous Hodge Slates, but the lower limit of this section is in contact with the intrusive serpentine.

This is unfortunate, since although many other fossil localities have been found, no section giving continuous outcrop from a horizon established by fossils to the base of the Dundas Group has been found. It is hoped that dendroids will be found under the Razorback Conglomerate on the crest of the spur east of the head of Spur Track II. The small tributary of White Spur Creek and Spur Track II would then provide almost a continuous outcrop westwards to the base of the Group. Unfortunately, dendroids are very difficult to find in these slates. Being to the east of the area, the degree of metamorphism is higher and they will not break evenly along the bedding planes. The fragments revealed on the rough surface are inconclusive and this was also the case in searching further north at Moore's Pimple.

The mapping and comparison of the lithology to some extent justify the placing of the Hodge Slates towards the base of the Dundas Group. A sequence such as basal tuff, Hodge Slates, Razorback Conglomerate and succeeding higher members would agree with the mapped data much better in the Carbine Track and Fahl syncline area. Also, although there are dissimilar phases, parts of the South Comet Grit resemble closely the Razorback beds. However, the basal tuff on the South Comet Creek contains trilobites and the fauna is thought to be very much lower than that found in the Hodge Slates. Therefore a section extending upwards to the Hodge Slates is proposed. The section on the upper end of Spur

Track II is chosen as the type section for the part of the Dundas Group below the Hodge Slates. An approximate 1,300 feet thickness of sediment occurs on this section from the Hodge Slates to the unconformity.

The age of the Dundas Group based on sound fossil evidence, was first adduced by Thomas and Henderson (1945) who recorded Middle Cambrian dendroids from the Hodge Slate near the Razorback. Later, trilobites were discovered by the author and others and these were determined by Opik (1951A and 1951B) who showed the presence of upper Middle Cambrian in the Dundas Group. More recent discoveries in other areas have extended the time range of the group into the Upper Cambrian.

The term "Dundas" was first applied to Tasmanian rocks of this area by Waller (1905, p. 623) and then by Ward (1909) who published the first definition of this group.

Judith Slate and Tuff

The basal bed of the Dundas Group is a tuff estimated to be 200 feet thick. It is a weathered, yellow, micaceous, gritty rock seen best in Judith Creek, but also exposed in the upper Frazer Creek area and in the Avon Rivulet. The basal tuff is not very thick and is interbedded with slate. The slate which has a very distinctive purple to purple-grey colour is a very fine silt but has numerous tuff beds in it. The purple Judith Slate occurs on Judith Creek, near the Platt workings, on the crest of the Comet-South Comet divide on the South Comet road, on Spur Track I, on Spur Track II, on the Moore's Pimple Track, on the timber haulage from Severn Rivulet to Higgins and near the Stables.

Fossils are found in basal tuff of the Judith Formation on the South Comet Creek at Station 38, 400 feet upstream from the junction of Stichtite Creek with the South Comet Creek. The fauna has not yet been fully determined but Opik (1951A and B) has provisionally determined *Lorenzella* sp., *Ptychagnostus* sp., *Pagetia* sp. and *Triplagnostus* sp., and has ascribed it to the upper half of the Middle Cambrian, well below the trilobites on Barker Creek and the dendroid fauna of the Hodge Slates.

South Comet Grit

In the South Comet Creek, 800 feet upstream from the South Comet dam, is a grey grit with an estimated thickness of 150 feet. It is highly siliceous, being composed of small angular fragments of grey and black chert set in a matrix of feldspathic tuff. It is a distinctive bed and is traceable for some distance, but it does not persist right round the central core.

Severn Slate

This formation, 800 feet thick, consists of purple and black slates interbedded with tuffs best exposed on upper Spur Track II. Many thin bands of tuff alternate with slates, giving a laminar appearance when the slate and tuff material are about equal constituents of the rock. When the tuff predominates, a dark-grey, massive, fine banded rock with dark wavy laminations results. This distinctive rock was observed outcropping north of Mount Razorback, on the Carbine Track, Spur Track II, Skinny

Creek and upper Montezuma Creek. There are thick beds of light-grey dolomitic tuff, both fine and coarse, which are best exposed on the Moore's Pimple Track, Spur Track II and Judith Creek. Among the many fine layers of tuff interbedded in the slates, intra-formational brecciation is common. Their description fits slates from other areas which have been called Farrell Slates.

The formation is represented in the South Comet area between the grit just upstream from the dam and the bold outcrop of Red Lead Conglomerate on top of the spur. The South Comet ore body occurs in these slates.

Red Lead Conglomerate and Tuff

In the South Comet Creek, just upstream from the Red Lead Mine, is a horizon of conglomerate 250 feet thick. Rounded siliceous pebbles of quartzite and chert are set in a gritty purple tuff matrix. The pebbles range in size from gravels to about one foot, but are mainly one to two inches in diameter. The conformable relation of this bed to the overlying fossiliferous Hodge Slates is quite clear.

A large bold outcrop of this conglomerate was examined on the spur above the South Comet Mine. It contains dark-grey banded chert, tuffaceous yellow sandstone, grey chert, banded slate fragments and fragments of a green jaspery substance. The pebbles are angular, subangular, and rounded, up to three feet across and down to very fine tuff. The whole is banded and stratified, with current bedding, and gradation is visible.

The conglomeratic facies does not persist right round the core but is represented by a medium to coarse gritty purple tuff, sometimes with occasional sparse pebbles.

On the upper South Comet Creek the sparse conglomeratic pebbles are set in a very fine purple silt matrix. It was this occurrence which was compared with the Zeehan Tillite near the Montana Western Mine.

Hodge Slate

This is the main fossiliferous horizon. The fossiliferous black micaceous slates are interbedded with and below the Razorback Conglomerate. There are some tuff beds and graphitic slates which contain a dendroid and hydroid fauna.

The main fossil locality is at the Hodge Tin Mine on the Razorback where dendroids were first recorded by Thomas and Henderson (1945). From a small quarry near a prospect on the Dundas-Comet road dendroids, a small trilobite pygidium and cystoid ossicles have been obtained. A tuff bed beneath the Razorback Conglomerate on the power line 100 yards west of the hut at Bonnie Point on the North-East Dundas Tram yielded trilobites of the agnostid group, *Solenoparia* sp., and *Bathyuriscidae*. A similar tuff bed in the first re-entrant east of Bonnie Point yielded agnostids (perhaps *Homagnostus*) and *Bathyuriscidae* (Opik, 1951A). The age is the same as the beds on the power line, the north-south Bonnie Fault having caused a repetition of the easterly dipping bed. Trilobite

fragments were also obtained from a tuff bed at this horizon beneath the Razorback Conglomerate on the east side of a steep spur north of the Moore's Pimple serpentine. Unfortunately, the dense forest covers the hillside and no bedrock is exposed. The fragments were found in a piece caught in the roots of a fallen tree and no more rock was available to persist with the search.

The dendroid localities are numerous and are indicated on the map. There are numerous places where dendroids are thought to occur, as likely fragments have been found, but only positive identifications are mapped. It should be pointed out that in many cases in order to establish a positive identification the search must be persisted with for some hours. This is especially true of the trilobite localities.

Lavas occur at this horizon. On the Ring River at Ringville and among the dendroid slates on the North-East Dundas Tram, just east of Montezuma, flows and tuffs are found. The flows are not so numerous nor so thick as those in the Curtin Davis Volcanics higher up, but it is thought that they tend to be more vesicular and scoriaceous than the more massive Curtin Davis flows.

The Hodge Slate fauna has been correlated with fossils obtained from a slate band in the keratophyric succession west of the Zeehan Basin. The age is Upper Middle Cambrian and the thickness of the Hodge Slates on the type section at the Razorback is 530 feet.

Razorback Conglomerate

This is a coarse grey conglomerate containing cherty and jasperoidal siliceous pebbles up to 6 inches in diameter, but mainly less than 1 inch. Both angular and rounded pebbles occur in a matrix of fine silicified grey tuff. They are often banded and mainly grey in colour, but some of the larger pebbles are of pink quartzite. Pieces of black slate and bright red and green fragments of jasper and chert have been found. The thick Moore's Pimple development, especially the upper beds, display these highly coloured fragments making an unusual and striking rock.

The beds are often only represented by thick coarse grey siliceous tuffs but these also contain fragments of black slate. The tuff beds contain occasional volcanic bombs. It is thought that the striated pebble found by Waller was obtained from this horizon.

Since this conglomerate is very different from other pyroclastic breccias of the Dundas Group it is used as a convenient marker bed in the field. The dendroids are found in the black slates just below it and if these are relatively unmetamorphosed, so that they can be split on the bedding planes, good correlation can be readily obtained. The thickness of the conglomerate is highly variable. The hard siliceous conglomerate stands up forming many ridges, and the rapid thickness variation is readily discernable. An average sort of thickness would be 400 to 500 feet. The exposure on the type section at the Razorback is 225 feet.

Curtin Davis Volcanics.

These do not occur in the type section but are well developed at Montezuma above the Razorback Conglomerate. They are a thick series of flows with interbedded coarse breccias, slates and tuffs. The margins and scoriaceous zones are mineralised and altered. The vesicles are chlorite filled and dolomitisation, silicification and pyritic mineralisation are common. Several mines and adits have been opened in pyritic ore bodies at the margins of the flows. Tetrahedrite, chalcopyrite, galena, sphalerite, bismuthinite and native copper have been won as ores.

The lavas have been described as pyroxene andesite, but are now thought to have been much more basic since slides approximating picrite basalt have been cut. The acidity of the " andesite " slide is probably due to subsequent silicification. The basic character of the rock permits a possible correlation with the King Island lavas (Scott, 1952). In suggesting a correlation with the lavas on the west side of the Zeehan Basin it is just possible that those beneath the Razorback Conglomerate may be equivalent to the Montana Melaphyre Volcanics while the higher Curtin Davis Volcanics may be the same age as the keratophyric tuff. The siliceous Razorback Conglomerate between would then correspond to the Nubeena Quartzite and Slate. The fossil evidence in so far as it is established is to the contrary, since it places the Hodge Slate and keratophyre tuff at the same horizon.

It is probably pointless to attempt correlation of lava flows since they are likely to occur at any horizon in the Middle Cambrian volcanic sedimentation. At least three lava horizons have been mapped in Dundas. The Curtin Davis Lavas are well exposed on the northern end of Goodkin Ridge and form the steep hillside above Montezuma. Their estimated thickness is approximately 1,000 feet.

Brewery Junction Slate and Tuff

These are soft yellow-brown slates with occasional bands of purple slate and breccia and many narrow tuff horizons. Light-grey, fine banded slates with occasional fine and coarse tuff beds occur repeatedly. The fine banding of these slates is characteristic and is accentuated by alternating laminae of black slate and tuff. The tuff beds markedly decrease in frequency and thickness towards the top of the formation indicating less volcanic activity and more normal deposition in the sedimentary basin.

These very thick sediments are exposed in the Dundas Rivulet from Dundas Railway Station to Brewery Junction. The less tuffaceous beds towards the top are less competent and have been deformed by a series of uniform folds about 30 feet across.

The thickness is 2,450 feet and probably represents most of the Upper Middle Cambrian, but no fossils have yet been found in these beds.

Fernfields Tuff and Conglomerate

The Fernfields Tuff and Conglomerate are exposed in the Dundas Rivulet between Brewery Junction and Fernfields Creek and are 1,950 feet thick in this section. The top of this formation resembles the West Coast Range Conglomerate. It is a coarse siliceous conglomerate with a tuff and

gravel matrix. Beneath this are purple slates with tuff and volcanic ejectamenta and a thick bed of purple slates with large sparse siliceous pebbles which possibly have a glacial origin. The bulk of the sediment is a coarse gritty purple tuff but pyroclastic fragments and siliceous gravels and pebbles occur throughout. The breccia towards the bottom tends to be more truly volcanic, since it is composed entirely of coarse tuff and tuff pebbles. Its contact with the underlying Brewery Junction Slates is very sharp.

Comet Slate and Tuff

The type section exposes the Comet Slate and Tuff in the Dundas Rivulet in the vicinity of Comet Creek junction and here it is 1,050 feet thick. Very thick beds of light-grey slates and tuffs with occasional grey-purple beds indicate further normal sedimentation with comparatively little volcanic activity. On Barker Creek is a well-bedded, grey-brown siltstone with slaty cleavage, which makes it fairly difficult to split on the bedding. This contains abundant fossils which include the trilobites *Blackwelderia* cf. *biloba* Kobayashi, *Conocephalites* (?), and *Anomocarella* (?) in addition to several agnostids (Opik, 1951A). On the power line, just east of Confidence Saddle, is a lava flow occurring in these slates. It is the highest flow noted in the Dundas Group.

Fernflow Conglomerate and Tuff

The Fernflow Conglomerate and Tuff is on the Dundas Rivulet in the vicinity of Fernflow Creek where the formation is 470 feet thick. Sparsely siliceous and tuffaceous conglomerate in a purple slate matrix and a similar conglomerate in a coarse tuff matrix are the main rock types. It is possible that these are dropped pebble beds and that this thin horizon is glacial. Purple and brown slates with sparse pebbles and water-sorted volcanic material also occur.

Climie Slate and Tuff

The Climie Slate and Tuff occurs near the junction of Climie Creek with the Dundas Rivulet and is approximately 2,000 feet thick. Grey purple slate, light grey slate, purple slate and tuff with coarser tuff beds and an occasional pyroclastic breccia indicate a period of relative volcanic quiescence. These beds have been regarded as the top of the Dundas Group, but actually the sedimentation is quite continuous with the conglomerate on Mount Misery which has previously been correlated with the West Coast Range Conglomerate. The alternation of conglomerates with slates is the main feature of the Dundas sedimentation. The tuff beds persist throughout but are much thicker and coarser in conjunction with the conglomerates. The siliceous conglomerates appear to follow the violent volcanic activity and may be due to the deepening of the sedimentary basin by rapid subsidence of the thick volcanics or possibly to concurrent glacial activity.

Misery Conglomerate

The lower beds of the conglomerate on Mount Misery interdigitate with green chloritic tuffs and grits. The thickness of the conglomerate is irregular. It occurs in lenses and beds which grade out to practically nothing and are interbedded with thick tuffs.

Although the conglomerate was for a long time regarded as West Coast Range Conglomerate there is a probability that the succeeding limestone is faulted or transgressive, and that the conglomerate is merely a very thick development of one of the conglomerates in the Dundas Group. In this case the top of the Dundas sedimentation is missing from the type section.

Junee Group

The only rock in the area assigned with certainty to this group is the Gordon Limestone on the flat west of Mount Misery. It forms the rim of the Zeehan Synclinal Basin.

Eldon Group

Conformably overlying the Ordovician limestone is the Eldon succession up to the Bell Shales. These beds are actually outside the area studied.

Permian System

The only other sedimentary rock in the area is the thin layer of Permian mudstone between the thin Jurassic dolerite sills on the summit of Mount Dundas. This elevated outlier is a small residual resting unconformably on Cambrian strata of the Carboniferous peneplain surface. Permian fossiliferous boulders are found in the Dundas Rivulet stream system.

Igneous Rocks

Serpentine

The transgressive serpentine sills are the important igneous rocks of the area. They have been regarded as contemporaneous with the Curtin Davis lavas but they transgress beds at the top of the Middle Cambrian. Some intrusions at least then are younger than Middle Cambrian. The serpentines are displaced by Devonian faulting and altered by Devonian mineralisation. They are older, and probably much older, than Devonian. Upper Cambrian is the most probable age.

The parent igneous magma for the serpentine was probably a bronzite, since kernels of this material have been found in boulders in the asbestos quarries on Five Mile Hill and over the Great Nevada asbestos adit. The intrusions have all been more or less completely serpentinised and asbestos occurs in many of them. The expansion due to hydration has caused crumpling, contortion and many minor faults and breaks in the surrounding rocks. Subsequent Devonian mineralisation has taken advantage of the disturbed zone, and silicification, dolomitisation and mineralisation of the serpentine margins are common.

Many ore bodies have been worked in the margin of the serpentine which has been the source of chromite, tin, copper, nickel, iron, sulphur and carbonates. There is reasonable prospect of finding further tin mineralisation associated with the margin of the serpentine in areas such as the Hodge workings or Pine Hill.

The very deep weathering of the serpentine is thought to be due largely to the Devonian hydrothermal activity. Wide aprons of decomposed rock occur in Dundas, especially at Kapi. The decayed serpentine resembles a red-brown tuff for which it has often been mistaken. How-

ever, there are still fragments of fresher serpentine and if the weathered rock is examined closely outlines of previously embedded crystals can be seen preserved in the decayed rock. On the map this weathered serpentine is not differentiated from the fresh, nor is the hydrothermally altered rock. Where the ultra-basic rock has reacted with acid magmatic fluids a suite of contact gabbros, hornblendite, feldspar porphyries and quartz porphyries has resulted.

The quartz porphyry sketched by Ward (1909) has been roughly indicated but although it was visited no attempt was made to map its boundaries in the field. They are largely covered by scree.

Jurassic Dolerite

Two thin dolerite sills occur on the summit of Mount Dundas. The lower is intruded along the unconformity at the top of the Cambrian rocks which were exposed during the Carboniferous peneplanation. It is overlain by a thin section of Permian mudstone followed by a second sill which forms the summit of Mount Dundas. The dolerite is similar to the large sills found in Eastern Tasmania but no very coarse-grained rock was seen.

A dyke of fine grained basic igneous rock outcrops on the Carbine Hill Track as it passes over the saddle, and another is seen in a cutting on Wallace's Tram where it cuts the Fernflow Conglomerate. There is no evidence to indicate that these dykes may not also be Jurassic in age, but it is quite possible that they are Tertiary.

Discussion on Stratigraphy

Structural Relations of Rock Groups

The Eldon Group forms the centre of the Zeehan Syncline and it conformably overlies the limestone and conglomerate of the Junee Group. Commonly an unconformity is found at the base of the Junee Group, as at Howth, Cethana and Tim Shea, but it is clear that the Cambrian succession underlies the conglomerate on Mount Misery without break. The upper beds of the Climie Slate and Tuff interdigitate with this conglomerate. However, it is not clear that the conglomerate on Mount Misery is West Coast Range Conglomerate as has been thought. Its lithology is similar to that of the West Coast Range Conglomerate, but other conglomerates lower in the Dundas Group, although they do not occur in thick beds, are also very similar. There are three possibilities for the relation of the Misery Conglomerate to the immediately succeeding limestone rim of the Zeehan basin:

(i) Assuming the Mount Misery Conglomerate to be merely a thick development of one of the conglomerates of the Dundas Group, the limestone may transgress over it as at West Zeehan.

(ii) The conglomerate may be faulted against the limestone. A major fault is known to pass across the limestone flat immediately west of Mount Misery. Supporting these possibilities is the continuation of Dundas Group rocks down the Dundas Rivulet, beyond the horizon of the Misery Conglomerate. Also the fossils found on Barker Creek indicate

the age of the Comet Slate and Tuff as Upper Middle Cambrian. This leaves only some 2,500 feet of sediment to represent most of the Upper Cambrian which is a period as long as the entire Permian. The unconformities beneath the West Coast Range Conglomerate in other parts of the State further support these two possibilities.

(iii) The conglomerate on Mount Misery has been regarded as West Coast Range Conglomerate and the sedimentation as continuous. Unfortunately, close examination of contact between the limestone and the conglomerate is precluded by the fall of scree from the steep western slope of the mountain on to the limestone flat.

Further work down the Dundas Rivulet from the Queenstown Road will perhaps give an indication as to which of these possibilities is correct. Meanwhile, the evidence is in favour of either transgression or faulting, which means that the Upper Cambrian sediments are missing from what has been defined in this paper as Dundas Group.

The thick Dundas succession rests unconformably on the contorted slates and quartzites of the Carbine Group. The only exposure of this unconformity seen is inconclusive but the evidence for a major break is strong. The junction of the Carbine Track and Wallace's Tram is on the upper Great Northern Creek at the Stables. Further up Wallace's Tram, 100 feet from the Stables, in the bank of a small tributary is exposed an irregular contact of slate and tuff. The slates are contorted and puckered and belong to the Carbine Group. The tuff is relatively unfolded and appears to be less altered. Since the exposure is only for a few feet, not enough of either bed can be seen to give the true relation. However, it does seem that the irregularities of the closely folded slates penetrate across the bedding of the tuff. Evidence of a fault nearby confuses the positive establishment of the tuff as basal in the Dundas Group. The Razorback Conglomerate occurs just downstream from the Stables and bears a faulted relation to the Carbine Group at the Stables. The whole of the Dundas Group from the Hodge Slate down is faulted out. Therefore, if this tuff belongs to the Judith Slate and Tuff it must be a small tongue remaining on the upthrown side of the fault.

The best evidence for the unconformity is in the Avon Rivulet in the vicinity of the track from Higgins to Moore's Pimple. The basal Dundas tuff bed here overlies first the slates and then the quartzites of the Carbine Group as it is traced round the contour. On Judith Creek also the marked change in metamorphic grade noted was put down to an unconformity as no evidence of faulting could be seen. The radical change of dips supports this but is not in itself conclusive evidence, as the folding of the lower members of the Dundas Group precludes constancy of dip direction for more than a few hundred feet. The Judith Creek section clearly establishes the Dundas-Carbine contact. Bedded primary dolomite is not found in the Dundas Group nor is purple slate found in the Carbine rocks. Sharply folded slates, however, are common to both.

The evidence set out above is supported by the mapped relationships of the rocks and in total is considered sufficient to postulate a major unconformity at the base of the Dundas Group. Fossil evidence indicates that the Judith Slates are the lowest of the three fossil zones, and probably Lower Middle Cambrian in age. This would put the depositional break in the Lower Cambrian.

The relationship of the Carbine Group to the schists of the Davey Group is not clear nor was the problem studied at length. A clear exposure of the unconformable contact of these beds with the Davey rocks would be required to show the relationship, since the close folding and fracturing make other evidence unreliable. Reid stated (1925, p. 7) "Directly succeeding, but unconformable with the Proterozoic schists, is a series of grey and black fissile slates, sandstones, conglomerates and quartzites . . ." However, he give no supporting evidence for this unconformity. It is doubtful whether an unconformity exists. The area mapped as Davey Group is determined solely on grade of metamorphism. In every traverse the boundary was established with difficulty, since it is entirely transitional. It is clear, however, that there are two groups of rocks. Once the transitional boundary is crossed the Davey rocks are entirely micaceous foliate schists, crenulated schists, high-grade phyllites and ropy quartz mica schists. The rock is dominantly quartzitic, being derived from argillaceous sandstones. On the other hand, although the Carbine rocks contain many, and often thick, quartzite horizons, they are dominantly slates, and contorted black slates occupy most of the area mapped as Carbine Group. The difference in lithology as distinct from the metamorphism warrants two formations. No fossils have been found in the Carbine Group and its age is still uncertain. It is thought to be Late Precambrian, but perhaps it extends into the Lower Cambrian. The Davey Group is certainly Precambrian.

Correlation of Dundas Group with other Areas

West Zeehan

The Dundas rocks dip westwards beneath the Zeehan Synclinal Basin. Their occurrence would then logically be expected on the west limb of the syncline. Here the West Coast Range Conglomerate is well represented on Mount Zeehan to the south of the syncline, but further north the thick development of conglomerate is missing and the succession found is:—

Limestone (Gordon Limestone)
Keratophyric tuffs and slates
Quartzites (Nubeena Quartzite and Slate)
Basic volcanics (Montana Melaphyre Volcanics)

Compared with the eastern limb of the syncline, these rocks have been altered, mineralised and subjected to complex folding and faulting. Because it is not so clear, the succession is not known in such detail as at Dundas.

Fossils were located in the Summit Cutting on the Comstock Tram in a comparatively unaltered black slate which would be at the base of the keratophyric tuff succession. The fauna is equivalent to that of the Hodge Slate at Dundas which is well down in the succession. It is just

possible that there is sufficient thickness in the keratophyric tuff for all the formations of the Dundas Group above the Hodge Slate to be represented.

On the T.L.E. Tram to the Swansea Mine, west of Zeehan, the distinctive lithology of the Razorback Conglomerate was recognised. Unfortunately, the grade of metamorphism is too high to allow dendroids to be found in the associated black slates and a positive correlation made. This bed is well below the fossils of the Summit Cutting, but the total thickness represented between the T.L.E. occurrence and the limestone on the rim of the Zeehan Synclinal Basin is only a little less than the 8,500 feet exposed on the type Dundas section, between Mount Misery and Mount Razorback. Nearby at the Swansea Mine is an outcrop of tillite of the Zeehan Glacials which is regarded as stratigraphically below the Razorback Conglomerate. Although metamorphosed the rock does resemble some of the conglomerate formations of the Dundas Group. It is made up of pebbles and boulders set in a feldspathic, gritty matrix. The Swansea occurrence compares with the Red Lead Conglomerate outcropping at the crest of the spur above the South Comet Mine. Structural and further palaeontological work will need to be done west of Zeehan to sort out the relation of the fossiliferous keratophyric tuff, the so-called Razorback Conglomerate, and the tillite.

A little further north, where the structure at the western margin of the Zeehan basin is more straightforward, a section was studied in detail to try to establish a correlation. Starting from the Zeehan Glacials, just east of the Montana Western Mine, a traverse was made to the limestone on Dunkley's Tram, over an easterly dipping sequence of finely bedded feldspathic shales and slates, tuff beds, quartzites and lava flows which occur immediately before the limestone.

The following similarities with the Dundas Group were noted:—

(i) Each succession of volcanic activity, i.e., lavas and tuffs, is followed by a thick series of slates or normal sediments.
(ii) The coarser tuffs resemble the Dundas pyroclastic breccias.
(iii) The lower lava flow resembles the Curtin Davis Volcanics.
(iv) The black slates and fine banded tuffs are dolomitised and are similar to those associated with Curtin Davis Volcanics.
(v) Some of the slates are similar, especially in the presence of numerous interbedded thin tuff beds.

The section differs from that of the Dundas Group in the following respects:—

(i) Total thicknesses of slate or "normal sedimentation" between the successive volcanic periods is much less, as is that of the volcanics themselves.
(ii) Coarse pyroclastic breccias and siliceous conglomerates do not occur.
(iii) Hard thick massive quartzites and pale-grey feldspathic slates do not occur in Dundas, but these may be due to alteration.
(iv) The degree of metamorphism is very much greater in this section. The slates are sub-phyllites and micas are developed in the tuff bands.
(v) The contortion and folding of the slates considerably exceeds that of the softest Dundas beds.
(vi) No amygdaloidal lava of the coarseness of the Montana Melaphyre Volcanics found just before the limestone, has been found among the Curtin Davis flows.

The similarities outweigh the differences, especially if the comparison is made with the lower Dundas Group from the Razorback marker down.

It is a reasonable assumption that the lavas are equivalent to those at Curtin Davis. The Zeehan Glacial Formation at the Montana Western Mine is conformable in this sequence, which indicates its stratigraphic position as below the Curtin Davis Volcanics and the Razorback Conglomerate. On comparing a fresh specimen of the tillite at Montana directly with a specimen obtained from high up the South Comet Creek it was agreed that they were identical, although the position of the South Comet Creek rock was obscure at this time. The rock in South Comet Creek is now regarded as Red Lead Conglomerate. Other higher conglomerates in the Dundas Group are also suspected of having a glacial origin.

Summarising all this evidence the following conclusions may be drawn:—

1. The limestone at the base of the Zeehan synclinal structure is transgressive. It is deposited over the West Coast Range Conglomerate at the south end of the basin and laps over successively older members of the Dundas Group northwards.
2. The keratophyric slate and tuff are equivalent to the upper formations of the Dundas Group.
3. The succession from the Montana Western Mine to Dunkley's Tram contains the Montana Melaphyre Volcanics. It is equivalent to the lower part of the Dundas Group.
4. The Zeehan Glacials are possibly equivalent to the Red Lead Conglomerate in the Dundas Group. If this is true the tillite can not be much older than Lower Middle Cambrian.
5. Glacial activity was probably contemporaneous with the early volcanic activity of the Cambrian sedimentation.

Poiseidon

A visit was made to the Poiseidon-Bon Accord area, west of Renison Bell, to attempt a correlation. This area is 4 or 5 miles to the northwest of Dundas. Although no positive fossil correlation was obtained, purple slates, pyroclastic breccias, tuffs and the Razorback Conglomerate were recognised, indicating that the rocks probably belong to the Dundas Group.

Hercules

A traverse was made from the Razorback Conglomerate northeastwards to the Hercules Mine, to correlate these rocks with the Dundas Group. The degree of metamorphism is high and increases eastwards. Since the structure is not entirely understood, it is not possible to obtain a rigorous correlation with the type section of the Dundas Group of which it should be the equivalent. Rocks traversed were:—

(i) Razorback Conglomerate: There is a thick development of this siliceous conglomerate on Moore's Pimple. The beds dip east so that this horizon is the lowest.
(ii) Thick dolomitic slates and tuffs (Brewery Junction).
(iii) Pyroclastics (Fernfields). The hydrothermal alteration has recrystallised the feldspathic tuff and large phenocrysts of feldspar are embedded in a light-grey matrix. The initial fragmental nature of the rock is still discernible but it is little wonder these rocks were earlier regarded as "porphyroids".
(iv) Further slates.
(v) A siliceous conglomerate which resembles the Razorback Conglomerate.
(vi) Slates.

(vii) Grey sheared dolomitic tuff. This is the host rock of the Hercules ore bodies.

(viii) Black slates. Because of their proximity to a tuff somewhat resembling an equivalent to the Razorback Conglomerate in Dundas they were examined for dendroids. The grade of metamorphism proved too high.

(ix) Sheared massive pyroclastics referred to locally as E.M.F. (Eastern Massive Fragmental). They have been described by Hills (1914B) under the heading of Read-Rosebery Schists and Felsites.

Mount Jukes

A sequence of slates and metamorphosed pyroclastics has been described from this field by Hills (1914A). A "brecciated conglomerate" is also discussed and appears from the description to correspond to one of the thicker Dundas pyroclastic formations.

Mount Farrell

In the purple Severn Slates many of the thin tuff lenses show intraformational brecciation. This and the rhythmically alternating bands of tuff and slate each about 2 inches thick make the rock quite distinctive. Rock of this type is recorded from Mount Farrell.

Leven Gorge

The Leven River, north of Gunn's Plains, cuts a section through a series of alternating slates, lavas, pyroclastics and tuffs.

Fossils have been found in one or two localities and correlated with the Barker Creek (Comet Slate and Tuff) fauna of upper Middle Cambrian age. It was also suggested by Opik (1951C) that a lower Upper Cambrian horizon in the Leven Gorge may be correlated with the upper fossiliferous horizon on the Huskisson River.

Huskisson River

The Huskisson River exposes a section of Cambrian rocks although they are of somewhat different lithology from that of the Dundas area. The vulcanism seems somewhat subdued in comparison with the type locality but the alternation of slates with conglomerates and tuffs persists. A fossil locality of Upper Cambrian age and another which may correspond to the Comet Slate and Tuff on Barker Creek have been found on the river section (Opik, 1951B).

Correlation of Carbine Group with other Areas

There is little positive data on which to base a rigorous correlation of Carbine rocks with others outside the area. The name Pieman Group was formerly given to these old closely folded slates and quartzites, volcanics and tillites below the Junee Group and younger than the old schists. This name therefore included both the Dundas and Carbine Groups as at present defined. The work in Dundas has established the relationships to the younger and older rocks so that the name Carbine Group will now apply to the older group around the central Dundas core. Reid (1925, p. 7), and Finucane (1947) have referred to these rocks as Bischoff Series, and they are described by Reid as similar to rocks at Rosebery and Mount Bischoff. They are probably equivalent.

The ore bearing slates and quartzites at Renison Bell were examined, and in view of their relation to the Dundas rocks immediately west in the Poiseidon-Bon Accord area they are almost certainly Carbine Group correlates.

In the group is a primary, bedded dolomite and it is probable that this is the equivalent of that found at Smithton and Black River.

Structural Geology

Folding

The structure of Dundas is essentially domal. The successively younger beds dip away from the central core of Davey Group schists. The Carbine Group is continuous round the core but is considerably thinner to the east. Folds of three magnitudes are present. The largest is the anticlinorium of the Dundas structural high on which there are four or five folds about half a mile wide and on these local folding occurs with interaxial distances of 50 to 100 yards.

The smaller folding can be readily determined locally by the dip observations and the usual field methods. The large domal structure can be determined on rock types but the intermediate folding is the most difficult. The beds are usually not discernible on the air photographs and cannot be traced by walking outcrops because exposures are mostly limited to creek beds. Fortunately, the faults can be traced on the aerial photographs and where their position is suspected confirmatory evidence is usually forthcoming. Careful mapping of the rock types and taking sufficient dip observations to be more or less statistical is the only method of working out the complex structure. This work is made difficult by the violent relief and vegetation which often made it almost impossible to obtain information where required.

The main fold axis of the Dundas anticlinal high trends north-east to south-west and pitches from central Dundas in these directions. A reversal of pitch to the north-east almost immediately brings up the Carbine rocks in the Concliffe re-entrant. This reversal persists across the northern boundary of the map and brings up the Carbine Group again at Renison Bell. To the east and west the beds in general dip away from the old core. However, the west limb is confused by the intrusion of large masses of serpentine. In the eastern margin of the Zeehan Basin is a bulge indicating some sort of a major depression. It is thought that this major cross structure persists across the Dundas area and is represented by the pitch reversal just indicated. On Colebrook Hill there would be the intersection of the two folds. The axis plunges to the south-west and passes out into a gentle fold in the younger sediments which merely lap round the anticlinal nose. The serpentine sill is intruded in this locality at the unconformity between the Dundas and Carbine Groups. It turns round over the plunging nose of the anticline showing up the fold. A small north-south trending fold on South Comet Creek is also reflected in the serpentine.

The Carbine Syncline is the next largest fold in the area. It is a trough extending south from Confidence Saddle to Carbine Hill where it turns west towards the Grand Prize Mine. It contains the younger Dundas rocks, such as are exposed on the type section, and which do not

occur elsewhere in the area mapped. It was from near the centre of this syncline that the abundant fossils of the Barker Creek locality were obtained.

The folding and faulting in the Bonnie Point corner is the most complex in the whole area. The rim of the Goodkin Syncline is visible on the aerial photographs since the almost vertical Razorback Conglomerate stands up as a strike ridge revealing the fold. However, this is the only fold in the area which is visible in this way. The northward pitch of these folds represents the regional dip away from the central core. The axis of the Dundas anticlinal high comes through just east of the Fahl Syncline and the marker bed is refolded on this complementary anticline to appear again in Concliffe Creek.

The Ramesdale Syncline is a smaller fold and is fairly simple although quite sharp. The marker on the west synclinal limb is readily traceable along the east side of the Great Northern Creek re-entrant. The fold is asymmetric, the west limb dipping gently and the east limb being almost vertical. The asymmetry and north pitch represent the regional dip away from the core. The complementary anticlinal crest to the west is missing, being faulted out by the Good Intent Fault. However, the structure is more or less part of the larger Carbine Syncline of which it represents the east limb.

The axis of the north-south trending Nevada Anticline passes in the vicinity of the Great Prize and southwards to the Nevada Mine where it turns eastwards; the core is occupied by the massive serpentine north of the Razorback. The marker horizon is anticlinally arched over the area, dipping north-east at the northern margin of the serpentine and south-west on Mount Razorback, which is a great strike ridge on the south-western margin. The successively younger beds then dip south-westwards in conformity with the structure of the large Zeehan Synclinal Basin.

The Carbine Group has undergone at least one additional orogeny and in consequence is much more closely folded. No serious attempt has been made to work out the detailed structure of the group but such a task, although extremely difficult, may be well rewarded as it is in this group that most of the mineral deposits occur. The massive quartzites fold competently with regard to the softer slates. They are brittle and fracture readily whereas the more plastic slates are rolled, puckered and contorted into fantastic shapes. Zig-zag folding seems to be characteristic of the thinner quartzite strata of the group, and invariably brecciation occurs in the apex of the folds. The mineralising solutions have taken advantage of the numerous fractures and folds to percolate through the rock depositing the valuable lodes. However, since the close folding and fracture of the rock are on a small scale, so also seems to be the deposition of ore.

Faulting

The complex faulting of the area was worked out mainly from the aerial photographs. The linear structures show up and were traced on the photographs. They were checked with recorded evidence of faulting from the field books and where not in agreement the existence of the faults was investigated in the field. Many of the linears were deleted

from the photographic interpretation when field evidence was not forthcoming. The fault pattern is dominantly north-south with repeated downthrow to the west. The Argent, Kapi and Concliffe Faults are the main ones of this pattern. None of the faults in the area is thought to be either Jurassic or Tertiary but it is quite possible that some of them may have moved again in these later times.

The Montezuma Thrust is a large overthrust upthrown from the west and displaying considerable lateral movement. It is actually fairly straight but the thrust apparently dips at a low angle (say 50°) to the west and it is the intersection of this inclined plane with the violent topography which is responsible for the irregularities of its trace on the map. The amount of movement on the thrust is not known but is estimated to be about 1,000 to 1,500 feet. The fault zone is quite wide and right along its length the rocks have been crushed and contorted for some distance on either side of the fault. This is especially noticeable where the thrust crosses the Carbine rocks and the old core. The fault zone is heavily mineralised and wide lenses of solid pyrite have been found. Carbonates and especially quartz veins occur along it and in the subsidiary fractures running from it.

The following data have a bearing on its age:—

(i) It cuts Davey and Carbine rocks and the rocks of the Dundas Group up to the lavas in the Upper Middle Cambrian.

(ii) It is heavily mineralised, presumably by the Devonian mineralisation.

(iii) It does not affect the Permian and dolerite capping of Mount Dundas under which it passes.

It is probably Devonian in age.

The Argent, Kapi and Concliffe Faults displace the serpentine and the sediments at the top of the Middle Cambrian. The Concliffe Fault does not seem to have disturbed the pre-Permian peneplain which it crosses just east of the summit of Mount Dundas. Moreover, they must be pre-mineralisation and Devonian seems a most probable age. The Argent Fault was not examined in the field but is thought to be contemporaneous with the Kapi and Concliffe Faults. All three faults downthrow to the west and tilt the strata eastwards so that a succession of blocks occurs with strata all east-dipping. The fault zones are more or less mineralised and some ore bodies occur, especially in Kapi Creek and on the saddle between Pine and Commonwealth Hills. This area might be worthy of closer investigation since the pre-serpentine fault would form a mineralising channel, which would allow extensive alteration of the ultrabasic rock.

The Severn Fault, which trends north-west is the oldest in the region since it is cut by the Montezuma Thrust and the Great Northern, Miklos and Good Intent Faults.

Other smaller faults include the West Comet, Kosminsky fractures, Red Lead, Platt, Fahl, Bonnie Faults and two small fractures west of Goodkin Ridge. All of these have valuable ore deposition on them. They may be considered as adjusting faults to the main fracture pattern.

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Locality Index

	Quadrangle International Grid (K/55)	Latitude	Longitude
Avon Rivulet	Zeehan 50	41° 50′	145° 27′
Barker Creek	Zeehan 50	41° 52′	145° 25′
Black River	Smithton 21	40° 53′	145° 18′
Bon Accord	Zeehan 50	41° 48′	145° 24′
Bonnie Point	Zeehan 50	41° 49′	145° 27′
Brewery Junction	Zeehan 50	41° 53′	145° 24′
Carbine Hill	Zeehan 50	41° 51′	145° 25′
Carbine Track	Zeehan 50	41° 51′	145° 26′
Cethana	Sheffield 37	41° 28′	146° 10′
Climie Creek	Zeehan 50	41° 55′	145° 24′
Colebrook Hill	Zeehan 50	41° 48′	145° 28′
Comet Creek	Zeehan 50	41° 53′	145° 25′
Comet Mine	Zeehan 50	41° 53′	145° 25′
Commonwealth Hill	Zeehan 50	41° 48′	145° 25′
Comstock Tram	Zeehan 50	41° 53′	145° 19′
Concert Creek	Zeehan 50	41° 52′	145° 26′
Concliffe Creek	Zeehan 50	41° 50′	145° 28′
Confidence Saddle	Zeehan 50	41° 49′	145° 25′
Curtin Davis Mine	Zeehan 50	41° 51′	145° 27′
Dundas	Zeehan 50	41° 53′	145° 24′
Dundas Rivulet	Zeehan 50	41° 55′	145° 22′
Dundas Station	Zeehan 50	41° 53′	145° 24′
Dunkley's Tram	Zeehan 50	41° 54′	145° 20′
Fernfields Creek	Zeehan 50	41° 53′	145° 24′

	Quadrangle International Grid (K/55)	Latitude	Longitude
Fernflow Creek	Zeehan 50	41° 54′	145° 23′
Five Mile Hill	Zeehan 50	41° 53′	145° 22′
Frazer Creek	Zeehan 50	41° 50′	145° 26′
Goodkin Ridge	Zeehan 50	41° 50′	145° 27′
Grand Prize Mine	Zeehan 50	41° 51′	145° 24′
Great Nevada Mine	Zeehan 50	41° 51′	145° 23′
Great Northern Creek	Zeehan 50	41° 50′	145° 26′
Gunn's Plains	Sheffield 37	41° 18′	146° 01′
Henty River	Strahan 57	42° 02′	145° 18′
Hercules Mine	Zeehan 50	41° 50′	145° 30′
Higgins	Zeehan 50	41° 51′	145° 26′
Hodge Tin Mine	Zeehan 50	41° 52′	145° 24′
Howth	Devonport 29	41° 05′	146° 01′
Huskisson River	Corinna 43	41° 39′	145° 27′
Judith Creek	Zeehan 50	41° 54′	145° 26′
Kapi	Zeehan 50	41° 49′	145° 25′
Kapi Creek	Zeehan 50	41° 49′	145° 25′
Leven Gorge	Devonport 29	41° 16′	146° 03′
Leven River	Devonport 29	41° 15′	146° 10′
Little Henty River	Zeehan 50	41° 56′	145° 11′
Maestries Station	Zeehan 50	41° 53′	145° 25′
Montana Western Mine	Zeehan 50	41° 51′	145° 17′
Montezuma	Zeehan 50	41° 50′	145° 27′
Montezuma Creek	Zeehan 50	41° 50′	145° 27′
Montezuma Falls	Zeehan 50	41° 50′	145° 27′
Moore's Pimple	Zeehan 50	41° 52′	145° 28′
Moore's Pimple Track	Zeehan 50	41° 52′	145° 27′
Mount Bischoff	Valentine's Peak 36	41° 26′	145° 31′
Mount Dundas	Zeehan 50	41° 55′	145° 27′
Mount Farrell	Mackintosh 44	41° 44′	145° 34′
Mount Jukes	Lyell 58	42° 11′	145° 36′
Mount Misery	Zeehan 50	41° 54′	145° 23′
Mount Razorback	Zeehan 50	41° 52′	145° 24′
Mount Read	Murchison 51	41° 51′	145° 32′
Mount Zeehan	Zeehan 50	41° 54′	145° 18′
North East Dundas Tram	Zeehan 50	41° 50′	145° 25′
Pieman River	Corinna 43	41° 40′	145° 08′
Pine Hill	Zeehan 50	41° 48′	145° 25′
Platt Prospect	Zeehan 50	41° 53′	145° 26′
Poiseidon	Zeehan 50	41° 48′	145° 24′
Queenstown Road	Zeehan 50	41° 55′	145° 22′
Red Lead Mine	Zeehan 50	41° 54′	145° 25′
Renison Bell	Zeehan 50	41° 48′	145° 25′
Ring River	Zeehan 50	41° 48′	145° 27′
Ringville	Zeehan 50	41° 48′	145° 27′
Rosebery	Murchison 51	41° 49′	145° 32′
Severn Rivulet	Zeehan 50	41° 50′	145° 27′
Skinny Creek	Zeehan 50	41° 54′	145° 25′
Smithton	Smithton 21	40° 52′	145° 07′
South Comet Creek	Zeehan 50	41° 54′	145° 25′
South Comet Mine	Zeehan 50	41° 54′	145° 25′
South Comet Road	Zeehan 50	41° 54′	145° 25′
Spur Track I	Zeehan 50	41° 53′	145° 26′
Spur Track II	Zeehan 50	41° 52′	145° 26′
Stables	Zeehan 50	41° 51′	145° 26′
Stichtite Creek	Zeehan 50	41° 54′	145° 25′
Summit Cutting	Zeehan 50	41° 53′	145° 19′
Swansea	Zeehan 50	41° 55′	145° 18′
Tim Shea	Huntly 73	42° 43′	146° 29′
T.L.E. Tram	Zeehan 50	41° 55′	145° 18′
Wallace's Tram	Zeehan 50	41° 50′	145° 25′
White Spur Creek	Zeehan 50	41° 53′	145° 29′
Zeehan	Zeehan 50	41° 53′	145° 20′

GEOLOGY OF TASMANIA

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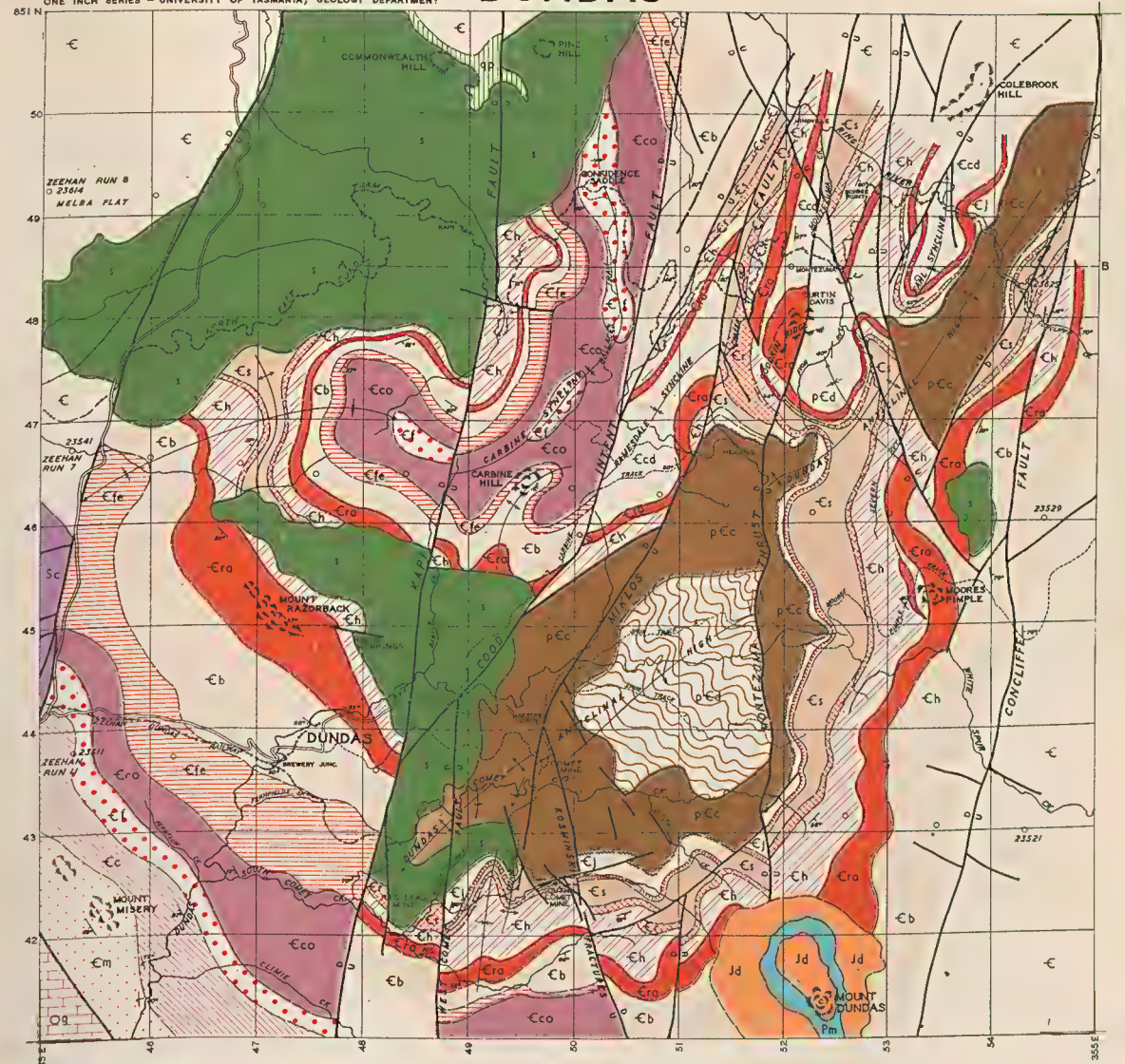
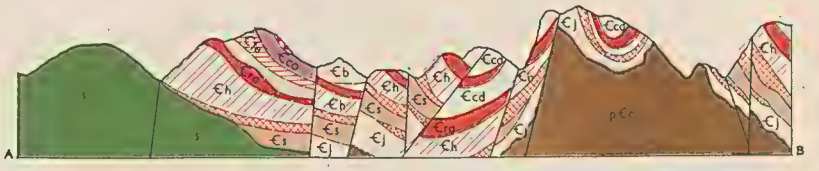
DUNDAS

345-841





Permian System

Pm MUDSTONE

Eldon Group

Sc CROTTY QUARTZITE

Junee Group

Qg GORDON LIMESTONE

Dundas Group

€m MISERY CONGLOMERATE

€c CLIMIE SLATE AND TUFF

€fe FERNFLOW CONGLOMERATE AND TUFF

€co COMET SLATE AND TUFF

€fe FERNFIELDS TUFF AND CONGLOMERATE

€b BREWERY JUNCTION SLATE AND TUFF

€cd CURTIN DAVIS VOLCANICS

€ra RAZORBACK CONGLOMERATE

€h HODGE SLATE

€r RED LEAD CONGLOMERATE AND TUFF

€s SEVERN SLATE

€sc SOUTH COMET GRIT

€j JUDITH SLATE AND TUFF

€ UNDIFFERENTIATED

Carbine Group

p€c SLATES, DOLOMITES AND QUARTZITES

Davey Group

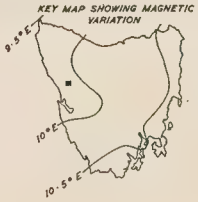
p€d SCHISTS

— SCALE —

0 1 2 MILES

0 1 2 3 4 5,000 10,000

KEY MAP SHOWING MAGNETIC VARIATION



Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Lands and Surveys Dept. Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

MAPPED AND COMPILED BY
J. N. ELLISTON JANUARY 1951

FAULT

FORMATION BOUNDARY

STRIKE AND DIP

ROADS

TRACKS

DISUSED TRAMWAY

IGNEOUS ROCKS

Jd JURASSIC DOLERITE

qp QUARTZ PORPHYRY

s SERPENTINE

Note on the Occurrence of Trace Elements in Clays of the Huon District

By

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Abstract

Samples of clays from localities in the Huon district were found to contain traces of nickel, copper, zinc, molybdenum, manganese and relatively large amounts of vanadium.

Introduction

Clays, consisting mainly of kaolinite were collected from the clay pit at Surges Bay, the foreshore of Killala Bay and the Granton Brick Company's clay pit at Dover. The clay from Surges Bay was formed by weathering of a syenite dyke and the Killala clay was formed by the weathering of the Ferntree Mudstone. The Dover clay was formed partly by weathering of Permian rocks and also by transportation and deposition of clay material from elsewhere. The elements were determined using colorimetric methods of estimation as given by Sandell (1950). The colours were developed and compared with standard graphs constructed using an E.E.L. photometric colorimeter. Elements sought in the investigation were copper, nickel, zinc, cobalt, lead, cadmium, chromium, molybdenum, manganese and vanadium. The study was suggested by Prof. S. W. Carey and carried out using equipment from the Chemistry Dept. by courtesy of Prof. E. E. Kurth. The amount of sample analysed was 0·5 gm. of dried clay. However, it was noticed that samples absorbed water during weighing.

Results of analyses

Copper, zinc, lead, and cadmium were estimated by comparing the colours of their dithizonates with standards. Cobalt and nickel were concentrated using dithizone. The blue colour of the cobalt thiocyanate complex was used for cobalt, and nickel was determined using the colour of the dimethylglyoxime complex. In the above estimations the samples were decomposed using perchloric and hydrofluoric acids. Sodium carbonate fusions were used to break down the samples for the determination of chromium, molybdenum, manganese, and vanadium. Di-phenylcarbazide was used to produce a chromium complex, ammonium thiocyanate and stannous chloride for molybdenum, potassium periodate for manganese, and vanadium was measured using the colour of phosphotungstovanadic acid after extraction with 8-hydroxyquinoline.

TABLE OF TRACE ELEMENTS FOUND IN HUON CLAYS
(in parts per million)

	Dover	Surges Bay	Killala
Cobalt	<10	<10	<10
Nickel	28–32	20–23	26–30
Copper	11–12	16	<1
Lead	<1	<1	<1
Zinc	20–24	28–30	17–19
Cadmium	<1	<1	<1
Chromium	<1	<1	<1
Molybdenum	4	6–8	14–15
Manganese	15–16	not found	trace
Vanadium	435–440	180–200	497–500

Where the amount is listed as less than a specified amount, it means that no reaction was found, when the sensitivity of the test was the specified amount.

Origin of trace elements

The origin of the trace elements is of interest. With the exception of vanadium and molybdenum the trace elements appear in lower concentrations than expected when compared with clay samples from other parts of the world. The concentration of nickel relative to cobalt is apparently due to the lack of iron in the clays, the latter usually being associated with iron in the geochemical cycle. The nickel concentration is similar to that found in non-ferrous aluminium-rich sediments. The actual origin of the nickel may be from small mineral fragments found in the clays. The variation of copper suggests that it is present as mineral fragments rather than as part of the clay mineral structure. Rankama and Sahama (1950) state that copper occurs in aluminous sediments by absorption. Green (1953) gives the average concentration of copper in shales as 192 ppm. The concentration of the copper is very much lower than average.

The concentration of zinc is low in all clays examined. It is possible for zinc to occur in the clay mineral structure by replacement of aluminium. This does not occur with pure kaolinite type clays. The zinc ion is very mobile in weathering processes hence it may have been largely leached from the clay materials. The greatest amount of zinc occurs at Surges Bay where it may have originated from the ferro-magnesian minerals of the syenite. Molybdenum is present in larger quantities than expected. Molybdenum is enriched in carbonaceous sediments. Its high concentration at Killala Bay may be due to the presence of numerous carbonaceous remains in the Permian rocks from which it was formed. The manganese has been leached from the clays by weathering processes hence not much was found in the analyses.

The high concentration of vanadium is interesting. During weathering processes vanadium is incorporated in clay minerals, by replacement of aluminium. The vanadium in the samples was also found to be concentrated in the clays and not in the silt fractions. It has been found that vanadium is enriched in carbonaceous sediments. The Permian mudstones from which the Killala clay has been formed, contain many carbonaceous markings and remains of fossil wood. Carbonaceous remains

also occur in the residual clay deposit at Dover. It is considered that the vanadium was derived from these and ultimately became incorporated in the clay by subsequent weathering processes. The transported clay at Dover has been considered to have been derived by weathering of dolerite which may contain appreciable traces of vanadium, Green (1953) considers that igneous rocks average 150 ppm. vanadium. The Surges Bay clay has less vanadium than the other deposits. The metal here could have come from ferro-magnesian minerals and apatite in the syenite. Vanadium can occur in apatite with V^{5+} replacing P^{5+}. Syenite generally contains about 30 ppm. vanadium.

Where high concentrations of vanadium are present the vanadium comes to the surface as a yellow-brown stain which becomes green on exposure to the air. This stain is common on Permian rocks in the area. Bricks made from the clay become green on exposure. Treatment of the green stain with dilute hydrochloric acid produces an orange precipitate which is soluble in the acid. If ammonia is used the green stain becomes blue and subsequently dissolves. It is suggested that an acid or alkali washing plant may be useful in removing vanadium from the clay. The vanadium however may not be released chemically until after firing in the kiln.

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Correlation of the Post-Triassic History of Tasmania with Secular Variation in Temperature and Viscosity of the Sub-Crust.

By

S. Warren Carey

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with 1 text figure

Abstract

The Post-Triassic igneous activity, sedimentation, epeirogeny, peneplanation, and faulting of Tasmania may be correlated genetically with secular variation in the temperture of the sub-crust.

The sequence of geological events in Tasmania since the Triassic, which has been summarised elsewhere by Carey (1946), may be tabulated as follows:—

1. Permian: Shallow transgressive sea over a region of substantial relief.
2. Triassic: Lacustrine sediments including coal seams. This sequence may extend into the Lower Jurassic.
3. Widespread invasion of Permian and Triassic sediments by thick sills and sheets of dolerite, resulting in plateau mountains perhaps 3000 feet above sea level.
4. Peneplanation lasting eighty million years or more which carved deeply into the Permo-Triassic sediments with their dolerite sills, producing a fairly mature peneplain.
5. Early Tertiary epoch of violent epeirogeny with strong block faulting and tilting, producing new relief some 5000 feet high, and a series of deep fault lakes which rapidly filled with sediments.
6. Early Miocene(?): Widespread extrusion of basalts over a surface of sharp relief.
7. New cycle of erosion with little subsequent movement.

In Figure 1 these events are correlated with the changing conditions of the sub-crust. The top curve shows qualitatively the implied temperature variation, indicated by the two epochs when the sub-crust was hot enough to produce very large volumes of basaltic magma. This is of course greatly oversimplified, for both these culminations probably had lesser culminations and there may well have been lesser intermediate fluctuations. But there can be little doubt that this curve represents the variation to the first harmonic which would be made more irregular by the changing temperature. Viscosity varies exponentially with plot them. The second curve shows qualitatively viscosity as implied by the changing temperature. Viscosity varies exponentially with

temperature, hence the downward troughs in this curve would be necessarily sharper than the corresponding temperature curve drawn with the same amplitude. (In this paper viscosity is used in its broad sense to include pseudo-viscosity of crystalline solids which is not Newtonian.) Let us follow out how this fluctuation in viscosity is expressed, in the sequence of geological events. During the early Permian the sediments themselves and their relation to basement indicate quite substantial relief which declined progressively into the Triassic, when well sorted and well rounded quartz sandstones and shales indicate subdued terrains and slow subsidence. The late Triassic includes tuffs, the first indication of the heating substratum. Meanwhile the declining viscosity of the substratum (and in consequence the crust) meant that stress differences which had been supported before could not be supported, so uplift commenced. By the time the sub-crust was hot enough to produce the dolerites the viscosity had declined to its minimum and the isostatic adjustment was as near perfect as it could be. The new relief was immediately subject to a new cycle of erosion, which would have resulted in some new departure from isostasy commencing from near zero and rising with time. But meanwhile the viscosity, at first at a minimum, was increasing rapidly with time, so there was increasing viscous resistance *pari passu* with the increasing isostatic load. By the late Cretaceous, peneplanation had reached an advanced stage so that very substantial uncompensated isostatic loads had been built up, but as the viscosity of the sub-crust was then at its maximum these loads could be borne without significant movement. However, the viscosity began to decline again whereas the isostatic load continued to increase (though at a diminishing rate), so the coming epeirogeny was inevitable.

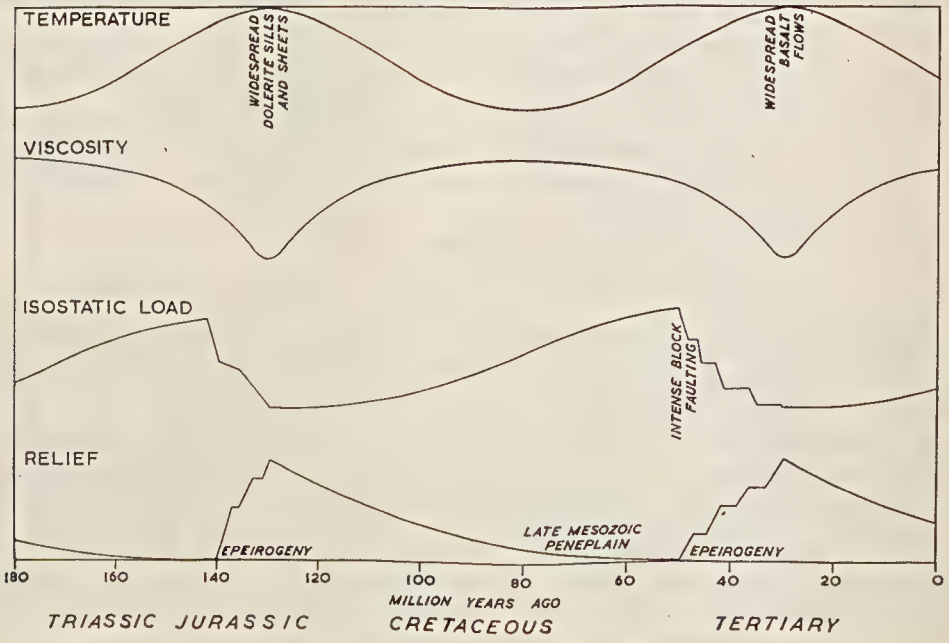

FIG. 1.—Post Triassic tectonics of Tasmania

This would appear first as an increasing rate of upwarp then, as the viscosity dropped steeply, the rate of adjustment would be too fast for quiet relaxation of the stresses, so the violent early Tertiary faulting ensued. By the time the highest temperature was reached the isostatic adjustment would be as complete as it could be, so the basalt floods in the main followed the epeirogeny (though very closely) and hence the basalts show very little sign of the epeirogenic disturbance.

The secular fluctuation in rheidity as illustrated above is of importance in interpreting large areas of one-sign gravity anomaly as evidence of strength of the earth's crust. Prior to the early Tertiary orogeny the cold crust below Tasmania was bearing the load which was subsequently adjusted at time of lower viscosity by a general uplift of 1000 metres. Since the density of the fluid displaced in the sub-crust is over 3, this means that the uncompensated load which the crust can bear in those regions where its secular temperature is low is at least of the order of 300 kg. per sq. cm. greater than in those sectors where higher sub-crustal temperatures prevail. Further, since it may be fairly assumed that the isostatic load was reduced to negligible amount at the time of the extrusion of the basalts, the total isostatic uplift indicates that loads equal to the weight of 1000 metres of substratum material (weight of fluid displaced) are ample to cause continuous flow in the substratum, and to rupture the crust at times of low viscosity, but are not sufficient to cause geologically rapid flow in the substratum in times or regions of secularly high viscosity. This means that the threshold for geologically rapid flow in the substratum varies from 10^8 dynes per sq. cm. or more, to perhaps 10^7 dynes per sq. cm. or less according to the secular condition of the crust.

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The Geology of the West Coast Range of Tasmania

Part I: Stratigraphy and Metasomatism

By

J. Bradley

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(with 4 text figures and 9 plates)

Abstract

The West Coast Range is a monadnock mountain chain of Tremadocian and older rocks. The Tremadoc strata were fault angle conglomerates which were crushed in Devonian times between a Cambrian geanticline and the Precambrian core of Tasmania. Cambrian rocks are of spilitic lavas and macigno facies greywackes. The Tremadocian strata are of Flysch and Molasse-like facies. Devonian movement was largely on the line of upthrust of the Cambrian geanticline and along this same line intense metasomatic metamorphism closely followed the Devonian orogeny. The juxtaposition of contemporaneous and later faulting with metamorphism and volcanic sedimentary and metamorphic breccias, provides interest. The two most interesting problems concern metamorphic contacts which resemble unconformities, and the tectonic history of the area. The phenomena observed can be welded into a consecutive story which is thought to be of world-wide application.

Introduction

This study is part of a wider programme of investigation into the mineral bearing region of Western Tasmania. The work, under the aegis of the University of Tasmania, has already resulted in descriptions of the stratigraphy and palaeontology of the Siluro-Devonian strata of the Zeehan district, by Gill and Banks (1950).

The Ordovician strata form the subject of another study; this article is concerned with the rocks and structures of the West Coast Range; with rocks which are in general of Cambrian age, unfossiliferous, metamorphosed, and cast in complex forms. In order to make a more complete picture of events, information has been supplied on districts outside the immediate area. This study is, unlike most petrological works, a field problem involving a high degree of structural interpretation. The results of field and structural studies are presented here, and at a later date a petrological and theoretical study of the porphyroid rocks and ore deposits will be given.

* This work was performed while the writer was a Research Fellow of the University of Tasmania

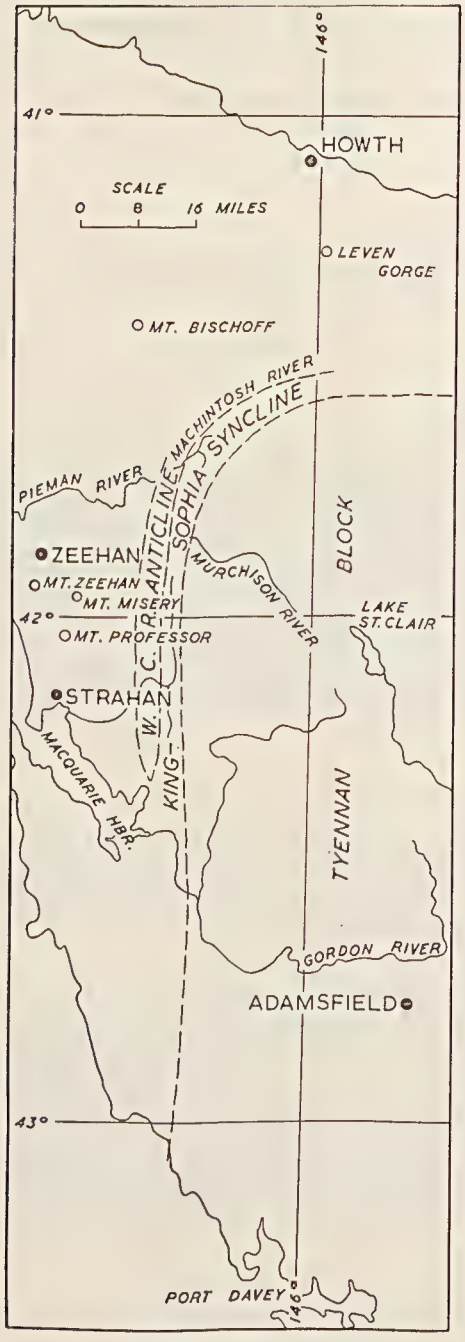

FIG. 1.—Locality map of part of Western Tasmania.

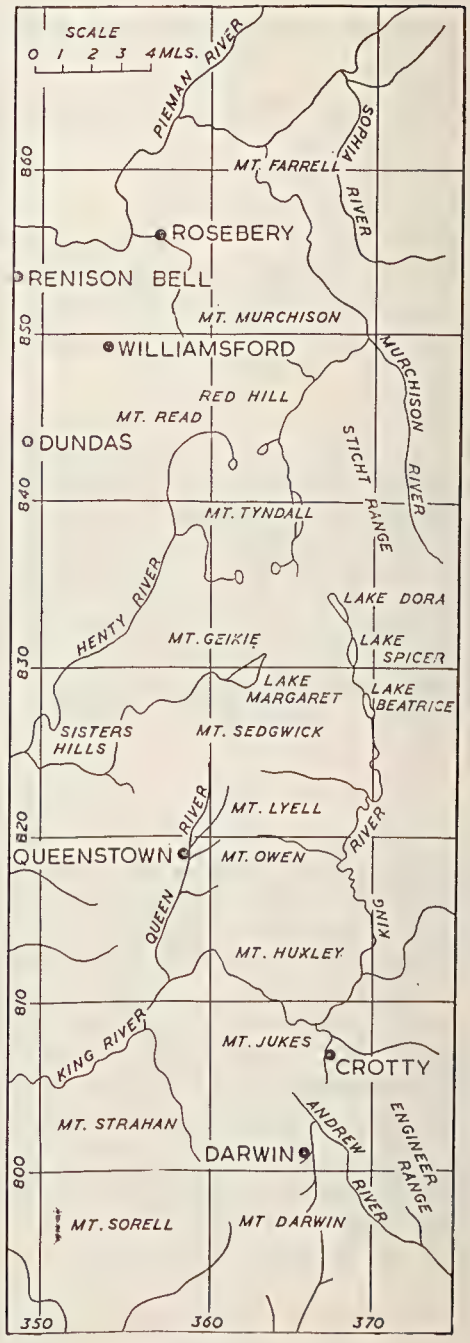

FIG. 2.—Index map of West Coast area.

LOCATION AND TOPOGRAPHY

The position of the West Coast Range is indicated in the maps, figs. 1 and 2, together with centres of mining and other localities mentioned in the text. The Range occupies a belt of country fringing the western margin of the Plateau of Central Tasmania. To the east the Range is separated from the plateau by a depression in which the major rivers run, while to the west the Range gives way to a broad low-lying country.

Considering the slight elevation (4,000 feet) of the West Coast Range, and its small range of altitudes (3,000 feet), it is a surprisingly rugged chain. Several factors contribute to this ruggedness, namely, the extremely varied hardnesses of the strata, glacial erosion, and the rejuvenation of rivers. The Range is a monadnock chain rising from the Howards Peneplain, a terrestrial erosion surface which falls from 1,000 feet at the foot of the Range, towards the coast. The surface of the plain is gently undulating and relieved by low quartzite monadnocks at Sisters Hills and Mt. Professor. Inland it forms the tops of the low 1,100 feet hills of the Andrew and King River Basins. A second erosional surface is the Henty Peneplain of Gregory (1903). This stands between 400 and 500 feet lower than the first and is the level of the old flood plain of the King River, and the flat valley floor of the Queen River. The coast of Western Tasmania is, apart from Flandrian drowning, emergent, and some of the uplift near Temma is very recent. There is abundant topographic evidence that the main uplift of the Henty Peneplain is relatively late, certainly post Pliocene. The rivers show all the characteristics of rejuvenation—gorges, rapids, falls, and discordant junctions. The heads of rejuvenation of large streams are situated, at relatively high altitudes, at short distances from the sea. The King and Henty rivers, for example, fall 600 feet and 500 feet respectively in the last twelve miles of their courses. In the case of the King River slow downcutting could be caused by barriers of quartzite which cross its course, but this is thought to be of secondary importance compared with lateness of uplift. Even the Howards Peneplain as a whole is at an early stage of dissection, and in this surface it is only the largest streams and rivers which have cut deep gorges. Between the King and Henty Rivers half the original land surface is undissected. This, in an area of 100-inch rainfall and of relatively unresistant rocks, suggests late uplift. The old surface is tilted seawards but does not reach to sea-level; it is interrupted on a line about one mile east of Strahan by a sudden drop to 200 feet. where it meets a horizontal surface of estuarine deposits. The line of contact of these surfaces is probably an old cliffed shore and an old fault line.

Inland, and along the Range, erosional and structural surfaces are apparent at several levels. The highest of these, at 4,500 feet, is the top of one of the dolerite sills characteristic of Tasmania. In this area the dolerite occurs at Eldon Peak and forms the peak of Mt. Sedgwick. More widespread is the second surface, a resurrected Carboniferous Peneplain (Edwards, 1941). This shows in the horizontal plateaux of Mts. Sedgwick and Dundas, both of which carry Permian tillite and " sugarloaf " dolerite remnants. It is seen more extensively in the concordant summits of the West Coast Range. Below the Carboniferous Peneplain a pro-

nounced erosional surface occurs at 2,750 feet; this is very prominent in the area east of Mt. Dundas, and remnants of it are present on Mt. Darwin, Mt. Farrell, and over much of the country east of the West Coast Range.

GLACIATION

Some of the glacial features of the Range are very fine and even exceptional. In the high country evidence of glaciation abounds, but nowhere is there a mature glaciated landscape. Only on Mts. Murchison and Jukes did cirques meet to form arêtes; elsewhere glacial erosion is even less mature. The Huntley cirque, cut in white quartzites and with a circular plan, is a typical example of biscuit cutting, and the erosion in the rest of the Tyndall Range, while it is the most extensive of the region, is of this type. Old valleys were ice-filled to plateau level, some were over-deepened and lakes, notably Lake Rolleston, were formed in them. Below 2,000 feet, and with the exception of Lake Spicer (900 feet), no over-deepened lakes and few glacial erosional forms occur. During the Pleistocene, the eastern side of the mountains was the lee side, as now, and it is there that cirques and ice-sharpened cliffs occur.

The largest of the glacial phenomena is the mammilation of the country of the Upper King Valley. This area, at 800 feet to 1,500 feet, was swept by an ice sheet which, descending from the Eldon Range, rounded off the hills and left tills and moraine which can be seen along the Lyell Highway. The ice travelled for a further three miles south, gouging out the cliffs of Little Owen (670/180), and leaving a heavy moraine at 670/160. No end-moraine now exists across the centre of the King Valley. This ice sheet must have piled up to a thickness of 700 feet at the King Bridge, for it backed up the ice of the Comstock and Linda Valleys, and some meltwater overflowed to the west. At Gormanston the varves, formed in the small lake extant before the melting ice, reached up to the level of " The Gap ", which was an overflow channel. Gregory's (1904) statement that the King River ice passed west of the Linda Valley is not borne out by the nature of the topography. In the Comstock Valley the limit of the ice is marked by the terminal moraine on the track to the Comstock mine. At the western end of the Comstock Lake the overflow cut a deep channel which is now occupied by the head of the West Queen River.

The most exceptional moraine in Tasmania is that below Lake Margaret. It was formed at the edge of the Mt. Sedgwick plateau, where the ice, descending rapidly, melted and built up a pile of debris on the plain below. The resulting asymmetrical moraine, 1,100 feet high on its western side, is unusual. It must include many stages of retreat of the glacier. The lower Yolande Moraine described by Lewis (1945) is very localised, small and eroded; it could have been formed by a small tongue of ice advancing after the formation of the bulk of the Margaret Moraine. It is not thought good evidence on which to base a thesis of glacial periods. The Henty Moraine reaches to the lowest level of any in this district—that is, to 400 feet. The moraine ends almost along the roadside, where the glacier was halted by a 400 feet high scarp. The glacier was not very thick, and as the Henty Valley is V rather than U

shaped, it cannot have been long occupied by ice. According to Lewis (1945), ice reached to sea-level at Malanna, but for evidence of this, in all the area of the Howards Peneplain, I have found no glacial erosional features nor glacial deposits. Gill and Banks (at Firewood Siding, Malanna) described Permian tillites which in a weathered condition look like Pleistocene till, and were probably taken to be of that age by David and Lewis (Lewis 1945).

DRAINAGE

The drainage system is closely related to the solid geology. The broad patterns of rivers are commanded by fold structures in the hard Cambrian rocks and the softer post Cambrian strata. The older rocks form the anticlinal core of the Range. The younger rocks overlying this core are stripped away, and along the flanks of the Range the Ordovician limestone is reduced by solution to below base level. Consequently the lofty Cambrian country is surrounded by wide swampy flats in which wind the King, Queen, Andrew, Sophia and Mackintosh rivers. In the centre of the broad synclines east and west of the Range the Siluro-Devonian sediments are reduced to low hills. Minor streams are closely controlled in trellis fashion, following the north-west and north-east joint patterns of the country. Middle courses of the larger rivers are incised following the Henty uplift, and the lower courses have super-imposed, mature patterns. The striking cross cutting relation of the King River to the West Coast Range is due in part to this superimposing. The river does, however, follow a structural low, and it must once have flowed only 500 feet above its present bed in a syncline of limestone. To the south, a much readier outlet exists for the waters of the King Basin through the low valleys of the Baxter and Andrew rivers. This is demonstrated by the recent capture by the Andrew of the headwaters of the Baxter, and the pending capture of the King. It appears that a much larger Baxter River must once have flowed north in order to have formed the mature valley which occurs near the Andrew Divide. The cross cutting relationship of the Mackintosh River to the Range has an explanation similar to that of the King, but this river is not appreciably incised. The Pieman River, into which the Mackintosh flows, is cut 200 feet below its old plain, and much of its course is unrelated to the structure of the country.

The Henty drainage had a base level about 400 feet above the present sea-level. The erosional cycle prior to that (the Howards) must have been very long. The ruggedness of the Range is most deceptive when estimating lengths of erosional periods, and the extreme chemical degradation of all but the quartzite rocks is the best index of the duration of that earlier cycle.

PREVIOUS LITERATURE

The mining fields of Zeehan, Dundas and Queenstown have attracted much attention, which has been devoted to the study of ores rather than to that of general geology. Many scattered and unco-ordinated observations have, at the same time, been made. A comprehensive account of earlier work at Lyell (meaning Mt. Lyell mines) is given by Gregory

(1905), who summarises the views of workers prior to that date. He gives an excellent history of the field, and description of the topography and climate. In the same area Hills (1913), Edwards (1939), and Conolly (1947), have made notable contributions to the geology. Hills first established the stratigraphic relations of the Cambro-Ordovician sediments and identified the main structures. Conolly has brought the structure at Lyell to a comprehensible stage and Edwards has given an account of mineragenesis. Tasmanian Survey officers have described other mining fields as follows:—Ward—Mt. Farrell (1908), Waller—Zeehan (1904), Hills—Darwin and Rosebery (1913 and 1914), and these accounts are referred to below. Before proceeding any further I must express my admiration for the work of the older geologists who have been a constant source of information through their faithful observations.

Maps of the area are:—the 4-inch to 1 mile sketch map by the Mines Department, and the 4 miles to 1-inch sheet, No. 3, by the Lands and Survey Department. Trigonometrical information is by courtesy of the Hydro-Electric Commission of Tasmania. The maps appended have been constructed wholly from aerial photographs (20 chains to 1 inch) by the writer, and produced by the Geology Department of the University of Tasmania. The maps of the area north of Lake Margaret await the availability of aerial photographs, and it is hoped to publish them in one year's time. Map references scattered in the text refer to the grid on the maps appended.

ACKNOWLEDGMENTS

This work was executed by me while a Research Fellow of the University of Tasmania, and I wish to express my thanks to that institution for financial support and the printing of the maps. My special thanks are due to Professor S. W. Carey for his advice and help. I wish to acknowledge also the friendship and valuable criticism of Dr. C. Loftus Hills and Mr. M. R. Banks, the drafting assistance of Miss June James, the companionship given me in the field by my friends, especially Mr. F. Brown, and the courtesies offered me by several mining companies. The Mt. Lyell Mining Company in particular has been most helpful in giving full access to their maps and property.

Incidental Stratigraphy

In this analysis it is primarily the Owen Conglomerate, the Dundas Group, the Porphyroid rocks and the structure which are of interest. These are treated in detail. Ordovician, Silurian and more recent rocks are used only as keys to structure, and are treated in detail only where they have particular interest.

RECENT

Because of rejuvenation it is only above nick points, in the Upper King and Mackintosh valleys, that recent river gravels have been deposited. There they cover the present flood plains and form low terraces of limited extent.

PLEISTOCENE

The most extensive Pleistocene deposits are the well-preserved river terraces of the middle course of the King River. They are aggradational deposits up to 100 feet thick and vary in texture from boulders to sand. The terraces are dated by a dry overflow channel which issues from the Toft Valley and cuts the highest of them. The absence of moraine across the main part of the valley, and the general form and age of the terraces, suggest that they are of fluvioglacial origin.

Of exceptional interest in Australia are the varves at Gormanston. They cover 10 acres and extend discontinuously over 300 feet of height, but are much less than that in thickness. Being highly variable, ill-graded, and containing numerous lenses of sand, gravel and dropped pebbles, the beds are not ideal examples of varves. It is probable that the Linda Lake was very limited and existed only at this one end of the valley and that the numerous drag structures of the varves are due to grounding and over-riding of advancing ice.

TERTIARY

Included here as latest Tertiary, and named Macquarie Beds, are the estuarine deposits bordering Macquarie Harbour. These are unconsolidated pebble beds, blown sand, lignitic coal seams and seat earths. Near Strahan 200 feet of beds dip gently west and pass below the water. On the western slopes of Mt. Sorell the beds standing at 400 feet also dip west. Around the harbour the formation is cliffed back, while inland there is an incipient dendritic dissection. Many of the valleys cut in the gravels are rounded off, grass covered and dry. At present the porous pebble beds appear able to dispose of all the rain, 40 inches, which falls on them. Presumably the valleys were cut at a time of greater rainfall or lower altitude. Around the Harbour and parallel to the shore run small folds which are slump structures consequent on cliffing. The effect of this slumping extends 50 yards back from the shore, as shown in the small faults of the railway cuttings east of Strahan. The dips at Strahan are, however, too consistent and strong to have this cause or to be initial dips. Rather, the beds appear to have been tilted and raised. Their uplift probably coincides with that of the Henty Peneplain and is possibly Pleistocene. No shelly fossils occur in the strata, but numerous plant remains may ultimately decide their age.

MESOZOIC INTRUSIVES

The small remnants of columnar dolerite capping Mts. Dundas and Sedgwick are clearly part of the basal sill of the plateau of Tasmania, and are post Triassic in age. The Sedgwick mass is described by Edwards (1942) as a quartz dolerite.

PERMIAN

Tillite occurs at Mt. Sedgwick, scattered across the plateau as large blocks bearing characteristic Spiriferids and Fenestellids in abundance. Below the dolerite 50 feet of these beds occur. Similar blocks and patches occur at Mt. Read near, and south of, the Hercules Open Cut. They show the Carboniferous Peneplain there to be an undulating surface with variations of up to 80 feet in height.

SILURO-DEVONIAN

Sediments of these periods constitute the Eldon Group of strata. They are arenaceous and argillaceous sediments overlying the Gordon Limestone. The uppermost limit of the group is undefined, as the strata are everywhere folded and eroded. At Zeehan, the type area, the formations of the group have been defined and described by Gill and Banks (1950), as follows:—

	Orogeny	
Lower Devonian	Bell Shale	1400′
	Florence Quartzite	1600′
Silurian	Keel Quartzite	400′
	Amber Slate	800′
	Crotty Quartzite	1600′
	Disconformity	

Gill (1950) identifies the Bell and Florence Formations as Lower Devonian in age, and provisionally draws the line between Silurian and Devonian at the base of the Florence Quartzite. He adds a proviso that the Keel and Amber Formations may also be Devonian. In the latter case there would be a considerable gap in the Silurian sequence. Despite this possibility there is usually no discordance between formations, and observations over a wide area indicate uniform condition of deposition for each formation. This is very clear, for example, in the case of the Crotty Quartzite, which over a distance of 40 miles is immediately recognisable by its lithology. The Keel Quartzite is also striking, as it forms a sharp ridge in all of the West Coast area. The Florence Quartzite is readily identifiable on the western side of the Range by its hummocky outcrop. In the King Valley it is not so readily identified from topography. In the same area the Bell Shale, which normally forms a negative feature in the Zeehan area, is also unidentifiable by any characteristic landscape form. This is because the pelitic formations of the King Valley are often slates. This is the case, for example, on the Lyell Highway, where the Bell Shales become a positive feature (3695/8195).

These points are of importance, as, in order to cover this area, considerable reliance is placed on aerial photographic interpretation. Not only is the area large but much is inaccessible; the Andrew Basin in particular is an almost impenetrable bush. Despite topographic variation, the Bell Shale is readily identifiable on the ground by the great thickness of shales or slates represented. On the Princess River this thickness exceeds that at Zeehan by more than 1,000 feet. There is a strong suggestion that the Florence Quartzites in this area are more shaly than at Zeehan—on the ground, at least, they are not readily distinguishable from the Bell Shale. Again, in the King Valley there may be some variation in the Crotty Quartzite, which on the Nelson River, 40 chains downstream from the road, is an impure limestone. This may simply reflect varying physiographic conditions, as the Crotty and the Florence Quartzites have been regarded by Gill as leached calcareous sandstones. The formation in the Nelson Valley would then simply be unleached Crotty Quartzite. It is noted in passing that the use of the term " quartzite " in regard to the Eldon formations does not mean silica cemented quartz sandstone but simply a quartz sandstone.

It will be apparent at this stage that the complete geomorphic adjustment to structure of the varied Eldon strata provides an ideal medium for photographic interpretation. Add to this the striking negative topography of the Ordovician limestones and the bold relief of the Owen Conglomerate, and there exists an area which for topographic interpretation of complex structures is unexcelled in any forested country. In the case of the Eldon Group it is generally possible, despite forest, to trace formations on photographs for many miles. Interruption by faulting is frequent, but little difficulty is met in matching beds and elucidating structures. The identification of formations and interpretation of structures are simple integrations of each other. The structural picture obtained by photographic mapping, assisted by lithology and dips, can be brought to a high degree of perfection.

Of the Eldon Group the Crotty Quartzite, whose recognition in the field is important, has some interesting features. The formation name derives from Crotty town (3675/8065) where the sandstone was first noted by Hills, but the recently formulated definition given by Gill and Banks (1950) at Zeehan is accepted. At Crotty Station the formation is well exposed. In descending order three members are recognised:—

(1) The Upper Tubicolar Sandstone. 200 feet. This is a porous white quartz sandstone with grains 0·5-1·0 mm. and bearing "pipe stems".

(2) Variegated Beds. 200 feet. These are very friable, pink, white, and green sandy shales and laminated sandstones; grain size less than 0·5 mm.

(3) Smelters Sandstone. 400 feet. A dazzling white, very friable and pure quartz sandstone. Grain size 0·5 mm. plus.

These sandstones are coarser than any other of the Eldon Group. They differ from the Crotty Quartzites at Zeehan only in that they contain no grit bands. Bedding is less regular than in other Eldon quartzites and cross bedding is common. The sandstone was calcareous, but the long exposure of the rock to peaty and sulphated waters has removed every trace of calcite. This accounts for the friable nature of the rock which on occasion is reduced to heaps of rubble. A common erosional slump breccia character of the rock is due to the same process of solution which removes the underlying Gordon Limestone. This occurs on an enormous scale on the roadside opposite the Lyell Smelters and produces anomalous structures. Such structures at the Queenstown Quarry resemble planes of unconformity or of thrusting.

The Tubicolar horizon, which here is distinguished from that in the Owen Conglomerate by the name Upper, represents a phase more than ordinarily calcareous. The "pipe stems" described by Ward at Zeehan as being parallel to bedding are, at Crotty, normal to the bedding. They have been described as casts of worm tubes or crinoid stems. I have found this bed to be very extensive and a consistent and useful marker horizon. The variegated beds are also useful in this respect as they are relatively rich in iron and stand out as bold bands in the sandstone.

The relation of the Crotty Quartzite to the underlying limestone is, because of the solution effects mentioned, rarely seen. Only one exposure of this boundary, at Bubbs Hill, is known; there appears to be a transition at that locality. At South Queenstown Quarry rolled fragments of lime-

stone are compatible with unconformity at this juncture, and the calcareous character of the sandstone could be attributed to incorporated limestone fragments. This possibility is thought to be slight. An interesting variation in the sandstone is its thinning from Zeehan to the south; from a reported 1,600 feet at Zeehan it falls to 1,000 feet at Queenstown and 800 feet at Crotty. On the King River section, towards Strahan, I cannot easily recognise it. Similarly, at Kelly Basin, the formation, though recognisable, is thin or is changing character.

ORDIVICIAN

The Ordovician is almost fully represented by the Gordon Limestone, which over most of the area extends from the Tremadocian upwards. The Tremadoc strata are in the main the Owen Conglomerate and are treated in detail separately below. The Gordon Limestone has not yet been clearly defined and this name, used on the suggestion of M. R. Banks, is an abbreviation of the customary " Gordon River Limestone ".

The formation has been traced round some 100 miles of outcrop by me, and at least twice that distance by Professor S. W. Carey. Its identity as one bed overlying the Owen Conglomerate is no longer in doubt. It is different from the section on the Gordon River at the Great Bend in respect of thickness, and probably of time range. In the West Coast Range its thickness is 700 feet as compared with 3,000 feet on the Gordon River. This is largely accounted for, in my opinion, by a transgressional relation from south to north, and by the replacement of the underlying Owen Conglomerate to the south by limestone. It may be that the Crotty Quartzite was later formed under conditions of regression, and that it, like the Owen Conglomerate, passes out to the south into limestone. Despite Gill's inclusion of the Crotty Quartzite with the Eldon Group, I anticipate that a large time-break will be found above, rather than below, this formation, and that Hills and Carey's (1949) inclusion of the Crotty in the Junee Group will prove to be a more reasonable arrangement. To the south of this area I expect there will be no Crotty Formation overlying the thicker limestone. The lithology of the limestone cannot be well described from this area as exposures are so poor. Excepting larger exposures on the Nora River, on the Nelson River, at Lynchford and Bubbs Hill, there are probably not twenty exposures of limestone of a total area of one acre in twelve square miles of " outcrop ".

At Zeehan, recent mine draining has lowered groundwater sufficiently to reveal a very rugged karst topography formed below the water table, with solution channels hundreds of feet below. Such a radical base levelling is the general fate of the limestone, which is traced everywhere by boggy flats carrying a black, carbonaceous ? residual clay. The recognition of the Crotty Quartzite and the Lower Tubicolar Sandstone are consequently more than ever important, as these sandstones indicate the presence and the thickness of the limestone. Such thicknesses as are given can therefore rarely be accurate within fifty feet, and, because of the slumping of the overlying strata, often have less accuracy than that. In view of the rarity of exposure it is small wonder that some writers considered the limestone to be a number of lenses. The limestone, where it is exposed, is usually dark-grey and often recrystallised and

coarse grained. At Lynchford Quarries it is pure, massive, and without bedding or many fossils. At Queenstown Quarry, and near its base, the limestone is impure and rhythmically banded with black shales. Here and across the river from the quarry it is highly fossiliferous; Hill and Edwards (1941) describe Ordovicion fossils from that locality, and Mr. M. Banks informs me that the latest collections show the limestone to extend from Lower Ordovician to Lower Silurian. On the Nora River great thicknesses of the limestone are very impure and may be more correctly called carbonaceous and calcareous shales. In this area (3648/7900) it is clear that the Lower Tubicolar Sandstones interdigitate with, and pass laterally into, the calcareous shales. The limestone, in the distance of three miles, south of that area, increases in thickness from 800 to 1,300 feet.

The base of the limestone has never been described previously. During the dry summer of 1950 it was possible to examine exposures at the head of Lake Margaret where Nye had previously reported limestone. The islands at the head of the lake, and the bed of the lake, were left high and dry. Limestones there are basal and transitional. They show the following sequence:—

Limestone 4 ft.	Dark, medium grained, with numerous bryozoa.
Limestone 40 ft.	Impure dark-grey limestone weathered to yellow sandstone with tubercles normal to bedding.
Shales 6 ft.	Yellow to black with many recumbent and graphitic tubercles parallel to bedding.
Sandstone 2 ft.	Yellow friable sandstone with small tubercles normal to bedding.
Gap 10 ft.	Apparently eroded shale.
Sandstone 40 ft.	White quartz sandstone.
Quartzite 60 ft.	Dense white quartzite.
Conglomerate 100 ft.	Grits and fine conglomerates.

The importance of the section lies in the information it gives on the nature of the transition and the character of the tubercles. The 40 feet limestone does not appear at first to be limestone. Rather it looks like, and is, the Lower Tubicolar Sandstone which is the uppermost member of the Owen Conglomerate. On smashing up this rock, to a depth of one foot or more, a core of blue-grey limestone, not obviously impure, remains. This limestone is crammed with bryozoa which pass into the tubercles of the weathered rock. A similar relation exists in regard to the 2 foot sandstone and its $\frac{1}{8}$-inch diameter branching tubercles. These have not been recorded before but are not uncommon in the Tubicolar Sandstone. The carbonaceous tubercles observed in the shales between the sandstone strongly suggest a vegetable origin. They are up to 10 inches long, $\frac{1}{4}$ inch wide, are flattened to $\frac{1}{8}$ inch thickness, and have a thin carbon coating. In and about this horizon flakes and thin bands of carbonaceous material are common. The presence elsewhere of similar flakes below the limestone is general in the country and they are met as far afield as on Dunkley's tram, four miles north of Zeehan, and in the Caroline Creek beds at Tim Shea.

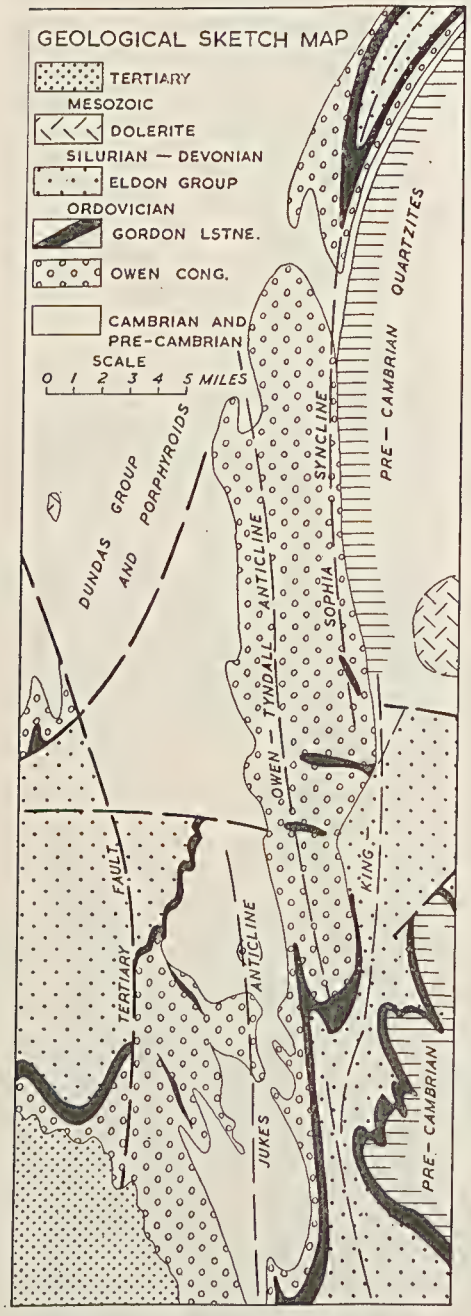

FIG. 3.—Geological sketch map of the area shown in Fig. 2.

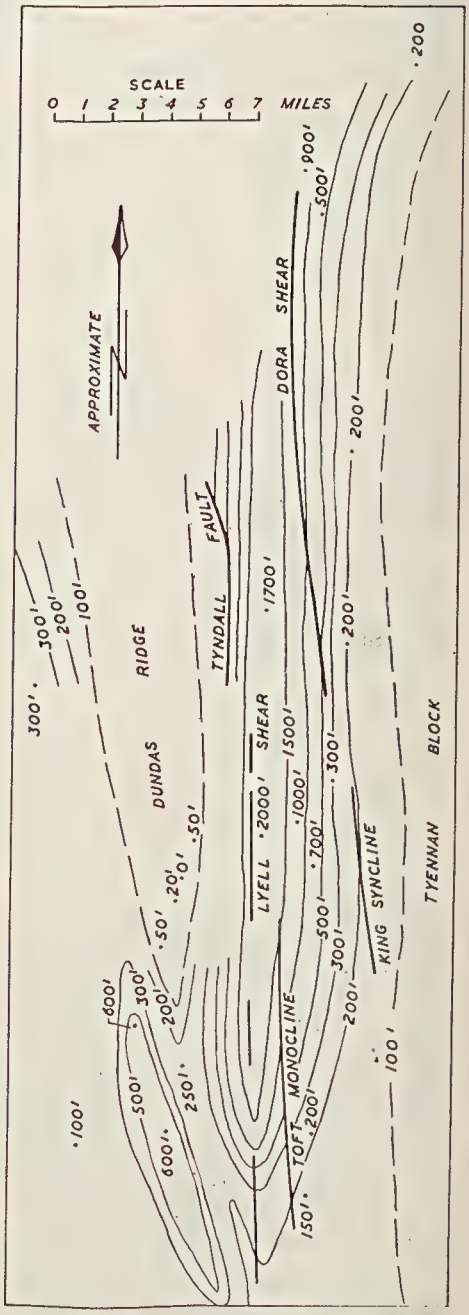

FIG. 4.—Isopach map of the Owen Conglomerate.

The Owen Conglomerate

LITHOLOGY

DEFINITION

The West Coast Range or Owen Conglomerate is a quartzose conglomeratic formation occupying the outcrops shown in Figs. 1 and 3. It lies principally in a narrow belt with little longitudinal variation in thickness but with a marked lens shape from east to west. Fig. 4 shows the estimated and deduced thicknesses of the formation in the West Coast Range. Outliers of similar but finer conglomerate occur to the west at Mt. Zeehan, Mt. Professor, Mt. Misery and Sisters Hills, and to the north are exposures at Howth, Dial Range and Leven Gorge. East of the Range thin sandy conglomerates occur at Hawks Creek, on the Sticht Range and Engineer Range, while to the south and south-east are exposures at Tim Shea, Adamsfield, and on the Denison and Elliot Ranges. Representatives occur, therefore, over an area of 150 by 100 miles. While it is probable that the uppermost sandy members once extended over this wide area, the conglomerate proper was laid down in distinct synclinal, fault, or erosional troughs of which the West Coast Range, or Jukes, Trough, bordering an old land, was the largest.

The conglomerate has long been loosely recognised by Survey officers as a formation. The earliest statement giving a name to the formation is that of Officer, Balfour and Hogg (1895), who published an adequate definition of the "Owen Conglomerates" occurring on Mt. Owen. In 1908 Ward further suggested that the conglomerates capping the Range were one formation, but the first precise account of any kind was that made by Hills (1913) on the succession at Mt. Jukes. Hills described the formation, which he called the West Coast Range Conglomerate, in clear accurate detail, and his description I have presented in a tabulated form below. Hills's section, a representative one showing the maximum development of the formation and most of its characters, runs as follows:—

Tubicolar Sandstone: yellow sandstone with pipe stems	400 ft.
Chocolate Sandstones: alternating thin beds of conglomerate, sandstone, and shale	400 ft.
White Conglomerates: quartz pebble beds with 1 to 2 inch rounded pebbles	400 ft.
Red Quartzite: Red or pink quartzite, fine grained, very hard, massive, but often fissured and veined	400 ft.
Red Conglomerates: Red quartzose beds with pebbles up to 6-inch diameter and often with haematitic cement	400 ft.
Breccia Conglomerates (= Jukes Breccia): Coarse breccias with angular to subangular fragments up to 4 feet across. Principally of porphyroid and slate fragments with subordinate quartz or quartzite. Usually deeply stained	300 ft.
Unconformity against underlying Porphyroid rocks.	

Hills emphasises the striking difference between the quartzose West Coast Range Conglomerate and the non-quartzose character of the underlying strata. He points out the almost universal silicification of the formation and its frequent veining by quartz and haematite. As evidence of unconformity, he points out the discordant relation of bedding on Mt. Jukes, the weathered appearance, schistosity, and different lithology of underlying beds, and the presence of igneous rocks of the underlying

formations in the basal breccias. The description is a faithful one and is acceptable except for an important qualification concerning the unconformity.

Hills has excellent grounds for supposing unconformity and in a general sense his statement is true. The writer would deduce unconformity near this juncture and in this vicinity, but it cannot be claimed that a clear unconformity is observed. The writer considers the contact to be metamorphic and not sedimentary. The discussion of this point must be delayed while a general picture is given.

The Owen Conglomerate is, as one would imagine from its conglomeratic nature, a variable formation, and from its distribution and thickness, has variable contacts with underlying strata. Further, much variation in its members is to be expected, and a type section cannot strictly describe the formation. Definition of the formation, as distinct from what is recognised as a description of a type section, can only be arrived at by qualifying the kind of variation from the norm which is to be allowed. The following criteria and qualifications are thought useful for defining the formation as a whole:—

1. The formation on grounds of priority and simplicity is to be called the Owen Conglomerate.
2. It is of Tremadocian Age (Hills and Carey (1949, p. 27)).
3. It is essentially quartzose. As this formation and some others are commonly silicified, this statement is qualified by requiring that the Owen Conglomerate contains more than 75 per cent of original quartz or quartzite particles.
4. It is normally conglomeratic but may contain shale and quartz-sandstone beds. Where the formation passes into shales it loses its identity, but where it passes into sandstones the name is retained.
5. It is limited above by the Gordon Limestone Formation. That boundary is often gradational but is normally fairly sharp at the Lower Tubicolar Sandstone.
6. The lateral sedimentary limits of the formation are:—
   (*a*) By transgressional unconformity.
   (*b*) By passage into shales and Gordon Limestone.
   (*c*) By passage into contemporaneous greywacke conglomerates and sandstones.
7. Its lower limit is defined by:—
   (*a*) Unconformity; basal breccias may or may not be present.
   (*b*) In the absence of unconformity, by a change in composition from greywacke type to quartzose sediments. The basal breccias are not always present, but there are very few cases where the change is not abrupt.
8. It may be limited laterally or terminate below by contact with metamorphosed rocks.

All of these conditions have been observed. The thickness of the formation ranges from zero to 2,000 feet and has no definitive value.

GENERAL

The following account is drawn from the area where the Owen Conglomerate is most typically developed, that is, the zone of thick, 1,000 feet-2,000 feet conglomerate, the axial belt of the West Coast Range.

Unfortunately, there can be little stratigraphic detail, because correlation of members inside of the formation is rendered very unreliable by the powerful transverse faulting and subsequent erosion which cuts the country into separate blocks. There are no fossils in the rocks and " walking " of beds is out of the question. There remains " bed for bed " correlation of the several blocks of country. Some results can be obtained by this method, but when it is considered that the east-west variation in thickness of the formation is from two thousand feet to zero in as little as six furlongs, it is rash to suppose that there is a vastly better consistency from north to south inside the formation. There are, however, some general observations which are useful, and some large unbroken blocks of country show the kind of continuity which can be expected. There is, in fact, a surprisingly consistent variation in the Owen Conglomerates, both vertically and longitudinally. Comparative sections have been drawn up, in the accompanying table, which show the broad character of the formation. A fuller account follows:—

PARTICLE SIZE

There is a decrease in pebble size from bottom to top of the formation. The basal breccias are always the coarsest and fragments are generally from six to eighteen inches across; fragments up to two feet are not unusual. The basal breccias are very unevenly sized, and resemble the deposits of a cliffed shore in a hard-rock terrain. The lower members of the Owen Conglomerate are of very even-sized quartz and quartzite pebbles which are rounded, slightly oblate or ellipsoidal, and six to nine inches long. The upper half of the formation shows decreasing grain sizes towards the top, and the gradually diminishing conglomerate bands are of pebbles two inches or less across. The pebbles are rounded, spheroidal, and are wholly of quartz and quartzite.

There is an increase in sandy members towards the top of the formation and, if the middle Red Quartzites are ignored, the gradation from coarse conglomerates to fine sandstones is very smooth. The Chocolate Shale is the finest member and consists of shale units which range up to 20 feet thick, alternating with grit and sandstone, in bands up to two feet thick.

The area at the northern end of the Tyndall Range is exceptional in several respects. There, although the uppermost 1,500 feet of the Owen Conglomerate are progressively finer upwards, the lower 500 feet are progressively finer downwards. Downwards there is also an increasing admixture of greywacke matrix and the formation passes into greywacke sediments. In the heart of the Tyndall anticline, on Newton Creek, occur shales which are interbedded in a 100 foot band low down in the conglomerate. The shales have been schisted to a sericite-chlorite phyllite or schist, whose schistosity is oriented in a drag fashion. The northern end of the Tyndall Range is also different in the fineness of its conglomerates as compared with those of the rest of the Range. Pebbles are rarely more than three inches across and the uppermost sandstones are very thick. There is a gradual change southwards along the Tyndall Range, until at the north end of Lake Margaret a considerable thickness of coarse pink conglomerates occurs. At that point there is still a great

thickness of white grits and fine conglomerate, but in the short distance to Mt. Sedgwick the sequence changes until it is very similar to the section of Mt. Jukes. It is possible to draw an east-west line through Lake Margaret to separate two areas in which conglomerates have an appreciable difference of pebble size. In each of these divisions there is a fair degree of consistency of members.

SILICIFICATION

The Owen Conglomerate is almost everywhere cemented into a solid mass by a cherty or chalcedonic matrix. This is most clearly demonstrated in localities like that on the roadside near Gormanston, where road cuttings show freshly blasted surfaces. The matrix there is dense and dark so that dark pebbles lose their identity in the mass, and the whole resembles specimens of the Rand Banket. There is a gradation of silicification which proceeds from intense in the lowest beds to less intense in the highest. This may simply be related to the original variation in permeability of members or it may indicate a deep seated source of silicifying solutions. It happens that the uppermost quartzites are often unsilicified and, in particular, that the bands enclosed in the Chocolate Shales are frequently unsilicified. Occasionally silicification reaches up into the Gordon Limestone, forming a porcellaneous creamy chert (3648/790). When fragments of similar chert are found in the higher conglomeratic beds, as they are at Tim Shea and near the Comstock Mine, it may be suspected that the conglomerate was not originally exclusively quartzose. In the lower beds chert pebbles never appear, but it may be that some few quartzite pebbles are coarse grained replacements of slaty material. Otherwise the exclusiveness of siliceous pebbles in the formation is inexplicable. The same explanation attaches to some of the fine grained quartzites which have microscopic grain sizes. Some look like current-bedded siltstones, but the yellow quartzites at Tim Shea look like finely banded shales. The latter are probably replacements, but it is impossible with some rocks to decide whether recrystallisation or replacement has been most important in their formation. On the whole, the quartzites were originally quartz sandstones, but a secondary origin must always be considered for the very fine quartzites.

WEATHERING

The conglomerate is reduced by a process of spalling, which occurs near or below soil level, and by chemical disintegration on exposed bluffs. Under atmospheric conditions the cherity matrix is sufficiently soluble to facilitate the loosening of pebbles, so that the surface of the rock is deeply etched, and detached pebbles fall to the ground. Because in some areas the exposed rock is ice scratched and still unetched, it is clear that the present corroded exposures are very ancient. As spalling also produces smooth fracture surfaces it is clear that the exposed bluffs with rugged surfaces have not recently been spalled. The spalling process is not the result of frost action or insolation but is somehow connected with the action of soil waters; such a process is not easily explained when the rocks are of chemically inert silica.

HAEMATITE STAINING

This also decreases upwards from the deep blue basal or contact rocks through the rose-pink and white conglomerates. The finer grained sediments are deeply stained irrespective of their position, and some of their colour may be due to an original high iron content. Staining, even in these beds, is always more intense when they happen to be close to metamorphic contacts. Thus, the Red Quartzite of Little Owen becomes purple when it lies in contact with the porphyries, and the Chocolate Shale in the North Lyell open cut is wholly replaced by haematite schist. The blue staining in the contact rocks is effected by haematite which occurs in masses or is diffused into the outer shell of quartz pebbles. The pink pebbles also show a shell, about 2 mm. thick of pink quartz, and in most quartzites the rose colour is completely diffused. Rather different is the colour of the Tubicolar Sandstone which is, except when close to a contact, yellow, due to iron hydroxides. As the hydroxides leach readily the Tubicolar Sandstone is often white.

CONTEMPORANEOUS MOVEMENT

At one locality an angular unconformity of 30° occurs at the base of the Tubicolar Sandstone. It is well exposed at the foot of the old haulage near Linda and has been mapped by Conolly and myself for about 200 yards. It is probable that the structure lies along a contemporaneous fault scarp and that slumping, or drag, and erosion have created a purely local unconformity. At the top of the haulage and along the track to West Lyell open cut occur some fine sandstone dykes. These dykes run through the conglomerate, about 90 ft. below the above mentioned unconformity. They are up to 50 ft. long and pass out of the conglomerate into the adjacent schists. The dykes observable in 100 yards of contact are up to four inches wide and are twelve in number. The infilling is of fine pink sandstone without bedding. These dykes, while straight in the conglomerate, have been intensely contorted and broken in the schists. These structures alone suggest the following:—

1. That there was contemporaneous movement which fissured the conglomerate.
2. That the schist-conglomerate contact is neither intrusive nor faulted.
3. Either—
   (*a*) the contact is an unconformity; or
   (*b*) the contact is metamorphic; i.e., the conglomerate has been replaced leaving the sandstone dykes unaltered.
4. That some plicating movement occurred at a later stage on the lower side of the contact line and that this movement and associated schisting post-date the conglomerate.

Slump structures in the conglomerate are unusual. They are very pronounced only in one area, on the Dora tram south of Lake Julia. There they occur in the transition beds at the base of the conglomerate. While they are individually only small, the movements are numerous and repeated over and over, and slumped beds are separated from other slumped beds by unslumped material. This kind of slumping is characteristic of active orogenic belts.

REACTION TO TECTONIC FORCES

Where the Owen Formation overlies plastic beds as at Mt. Tyndall, it has behaved in a competent fashion. Where the underlying rocks were the hard Cambrian strata the thrusts now pass from these rocks and die out into folds in the 1,500 ft. thickness of conglomerate. While the pebbles are rarely, if ever, drawn out, there must have been much movement of pebbles; this is rarely obvious. Where pebbles lack sphericity their rotation can be observed and can be associated with the drag on particular faults. This is true of the Lyell Shear at South Darwin Peak; as rotation would be impossible in a silicified rock it can be postulated that silicification postdated this fault. Similarly, the absence of drag shears in most folds points to the same conclusion regarding folding. On the other hand, the brecciation of silicified conglomerates at Comstock and North Lyell means that some movement, particularly on north-east faults, postdated or was contemporaneous with silicification. Hills remarked on the strong fissuring of the Red Quartzites as compared with the conglomerate beds; that difference reflects the different abilities of the beds to transmit shearing forces. Even if there were no differential metamorphic effects it is evident that the pebble beds, with so little matrix, would react under compression or shear quite differently from other strata. They could conform like a layer of ball bearings while beds below were schisted and those above were occasionally converted to slate.

THE JUKES TROUGH

The regular grading of the individual members of the conglomerate formation rules out a fluviatile origin for it, and the coarseness and small amount of fine matrix in the lower beds rules out an origin by deposition on a sheltered sea coast. The environment was one of swift currents which rounded pebbles and swept away fine debris. It is imagined that there was a fault coast along the western margin of the Tyennan Block, and that the deposition basin was a narrow strait separating that coast from an island chain some four miles offshore. It is conceived that the trough continuously subsided along its western margin and that thick deposits were formed there. The trough can be roughly divided into an area north of Lake Margaret, where sediments were, on the whole, finer, and one to the south where they were coarser. Further south the strait passed out into open and deep water. The trough is named the Jukes Trough and the offshore chain the Dundas Ridge. The latter appears to be related to the Bischoff Anticlinorium (Carey, 1953, p. 1119 and Fig. 3).

THE BASE OF THE OWEN CONGLOMERATE

The basal breccias denote a major change in the character of sedimentation. On the Tyennan Block unconformity occurs at this level, and although there is conformity in the Jukes Trough there is an abrupt change from greywacke to quartzitic sedimentation.

Typically, the breccias are less than fifty feet thick and are a heterogeneous unbedded mass of unsorted angular and subangular material. Fragments are huge boulders, blocks and slabs of granite, porphyry, schist and slate which might have been locally derived, and of quartzite, haematite schist and massive haematite which appear to be exotic. In the Jukes Trough the Owen Conglomerate is conformably underlain by greywacke conglomerate, and it appears that the breccias were derived from low fault scarps along each side of the trough. The complete change in the fill material of the trough implies movements over a vast area, movements which at once cut off supplies of greywacke and instituted a source of coarse quartzitic detritus, movements which must have almost submerged the Dundas Ridge while elevating the Tyennan Block. It is readily conceived that an even earlier rise of the Dundas Ridge must have produced an unconformity at the base of the greywacke conglomerates. Some confusion has arisen from the fact that Hills and Carey correlated (1949, p. 25) the greywacke conglomerates on the Lyell Highway above the King River Bridge (towards the Linda Valley) with the Jukes Breccia on Mt. Jukes, whereas only the upper part of this conglomerate should be correlated with the Jukes Breccia. The writer proposes that the lower part of this Lyell Highway section, i.e., the greywacke conglomerate, be taken as a separate formation. This will be called the Dora Conglomerate.

The Dora Conglomerate is widely exposed in the glaciated surfaces of the type area around the shores of Lake Dora and for half a mile to the east and west of the lake. The formation is of Upper Cambrian age and lies conformably below the Jukes Breccia but this conformity is expected to pass into unconformity in places. The formation is inferred to be unconformable on Middle Cambrian and on Precambrian strata. The formation is characteristically an ill-sorted greywacke conglomerate with much fine matrix. Pebbles, which vary in size from one to six inches, are rounded and, though tabular or elongate, are not angular. The top of the formation is normally marked by a clean break from, or rapid transition into, the Jukes Breccia. The base of the formation is not definable owing to metamorphic transition. The full thickness of the formation may be very great, and at Lake Dora it is probably between 2,000 ft. and 3,000 ft. thick. As it is probable that the formation was deposited in a trough on one side of the Dundas Ridge it is distinguished in this paper from the Lynch Conglomerate of the Queenstown area, which was deposited in a separate basin on the western side of the Ridge.

The Jukes Breccia is regarded as the basal member of the Owen Conglomerate. It is a breccia which is characterictically coarser than the overlying conglomerates and contains quartz fragments. The Jukes Breccia often contains material common to underlying formations and is usually intensely haematite stained. It is unconformable on Precambrian rocks of the Tyennan Block and probably on the Cambrian strata of the Dundas Ridge, i.e., on the Dundas Group and on the Dora Conglomerate. In the West Coast Range the Jukes Breccia is often seen to be conformable on the Dora Conglomerate.

TABLE OF RELATIONS OF THE

EAST — NORTH — THICKNESS ESTIMATED IN FEET

TYENNAN BLOCK

Tim Shea (and probable general relation in Tyenna)

Gordon Limestone		
Shaly fossiliferous Limestone	=	Caroline Creek Beds
Tubicolar Sandstone and fine conglomerates	200	
Ultra-fine yellow quartzites	100	
Conglomerate, grading down into	100	
Jukes Breccias with dolomite	50–200	

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Angular unconformity on eroded dolomite and plicated quartzite. (known Precambrian)

EAST LIMB OF KING-SOPHIA SYNCLINE

Hawks Creek		*Sticht Range*	
Gordon Limestone		Fine Quartzite	300
Quartzitic Grit	200	Conglomerate (Owen)	100
* * * * * * *		* * * * * * *	
Granite Dora Cong.	800		
Hypothesised unconformity			
Plicated Quartzite		Plicated Quartzites	

EAST LIMB OF MAIN ANTICLINE

S.W. Mt. Farell		*Lake Dora*	
Tubicolar Sandstone	300	Sandy Conglomerate	400
Conglomerate (Owen)	200	Jukes Breccia / Haematite Zone	50
Quartz Porpy.—Biotite Granite		Dora Conglomerate	
		Pyritic chlorite schist	
		Dora Conglomerate (Porphyry)	

AXIAL BELT

Mt. Farrell		*Red Hills*		*Mt. Tyndall*		*Mt. Sedgwick*	
Tub. Sstne.	300	Tub. Sstne.	300	Quartzite	700	Tub. Sstne.	350
Congl.	700	Congl.	500	Congl.	600	White Cong.	500
Haematite Zone		Jukes Brec. / Haematite	60	Phyllite	100	Red. Qtzite.	200
				Cong.	200	Red Cong.	600
Syenite to chloritic Greywacke				Sub. greyw. trans. into Greywacke silts	600	Jukes Brec. / Haem. Zone	60
???		Felsp. porphy.	150				
Farrell Slate		Pyritic Zone	150	??		Dora Cong.	800+
		Felsp. Por.					

WEST MARGIN DUNDAS RIDGE

Mt. Misery		*Queenstown Smelters*	
Tub. Sstne. with Cong. bands	100	Fine Quartzose Grit with greyw. matrix	80
Red Greywacke silts with Qtz. Grit bands	200	Varvoid clays	100
Chloritic Greywacke with Cherty Conglomerates	1200	Chloritised and kaolinised Greywacke	

ZEEHAN BASIN — WEST

Sisters Hills	
White Quartzites	150
White Conglomerate	150
Yellow Shales	500
Lynch Conglomerate	2000
Chloritised gradational contact	
Quartz porphyry	

OWEN CONGLOMERATE TO UNDERLYING ROCKS

UNCONFORMITY * * * METAMORPHIC BOUNDARY.....SOUTH

Adamsfield (probable south margin of Tyenna)

Gordon Limestone	200
Quartzites	200
Conglomerates	600
Jukes Breccia of serpentine	60

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Angular unconformity on Cambrian pyroxenites

Raglan Range

Red Quartzites 80

Engineer Range

Red Quartzite 200

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Plicated Quartzite; probably Precambrian

Lyell Peak

Tub. Sstne.	500
White Cong.	400
Red Qtzite.	200
Red. Cong.	300
Jukes Breccia / Haem. Zone	60
Dora Cong. (Qtz. porphyry)	800

Crotty

Tub. Sstne.	400
White Cong.	600
gradational change to Sericite chlorite schist	

Darwin Town

Tub. Sstne. / Cong. & Grit	200
Finely bedded chloritic cong. (greywacke)	600
Chlorite schist	

Ten Mile Hill

Fine grained Conglomerate (Owen)	200
???	
Chlorite sericite schist	

West Lyell

Tub. Sstne.	300
Choc. Shale	200
White Cong.	500
Red Qtzte.	200
Red Cong.	400
Haem. Zone	
Lyell Schist = Porphyry	

Mt. Jukes

Tub. Sstne.	300
Choc. Shale	100
White. Cong.	400
Red Qtzte.	400
Red Cong.	400
Jukes Brec. / Haem. Zone	60
Dora Cong.	300

Snake Spur

Tub. Sstne.	200
Haem. Zone	15
Felsp. Porph.	
Pyritic Zone	
Felsp. Porph.	
Porphyries = Owen Cong.	

South Darwin

Red Quartzite	400
Conglomerate and Grit.	200
Jukes Brec. / Haem. Zone	40
Granite and Hornfels.	

Lynch Creek

Red Quartzite	10
Quartzose greyw.	15
Varved clays	200
Lynch Cong.	
Battery Volcs.	
Miners Slate	
gradational change to Quartz porphyry	

Currie River

Red Quartzite	150
Conglomerate	100
Jukes Brec. / Haem. Zone	50
Sericite—chlor. schist.	

Clark River

Red Quartzite	200
Chloritic greywacke shales	
—gradational change to Schist.	

Mt. Sorell

White Quartzites	500
Conglomerates	100
Sorell Conglomerate (haematite zone)	= 500
Quartz porphyry and ? granite	

BASAL AND MARGINAL FACIES OF THE OWEN CONGLOMERATES

The Axial Belt of the Range (from North to South)

MT. FARRELL

The coarse (3 inch) Owen Conglomerate overlies, with an abrupt change, similarly sized chloritised greywacke. There are no signs of unconformity or of conformity, as the sheared chloritic rocks do not provide good evidence. In this vicinity the base of the conglomerate is not very rich in haematite and the greywackes are feldspathised in bands mapped by Ward as intrusive syenites.

LITTLE FARRELL AND MURCHISON RIVER

On Little Farrell and in the Murchison Gorge the basal rocks are normal Owen Conglomerate but are rich in haematite, which occurs in the massive form as pebbles and interstitially as specular crystals. The underlying rock varies from quartz porphyry on Little Farrell to syenite and granite in the Murchison Gorge. These " igneous " rocks are metamorphosed conglomerates, and the relict bedding seen in the porphyries is conformable to that in the Owen Conglomerate. Veins of haematite, pyrite and quartz run out of the granite into the Owen Conglomerate.

MT. MURCHISON

Three hundred yards north-east of the northernmost of the Red Hills copper prospects lies the best exposure yet found of the Jukes Breccia. It is 50 ft. thick and contains slightly rounded 3 ft. cubic blocks of quartzite, 2 ft. slabs of slate and rounded quartz porphyry boulders. The rocks are haematitic and contain 2 ft. slabs of haematitic schist whose source is unknown. The underlying strata are perfectly conformable " greywackes ". They are conglomerates with pebbles up to 3 inches, but with much fine material as matrix and as bands. Both pebbles and matrix contain feldspar porphyroblasts and are petrologically feldspar porphyry. Feldspar porphyry is not represented in the breccia, nor are any of the breccia rocks present in the porphyries. At least 100 yards of exposed contact is seen. Important points about the contact and porphyry rocks are as follows:—

1. The change in rock type is often complete in one inch and usually in 3 ft.
2. The rock types are texturally different. The underlying rock is not well graded and is texturally distinct from the Owen Conglomerate or the Jukes Breccia.
3. The contact is a conformable one but it suggests some unconformity nearby.
4. The contact marks the margin of a metamorphic zone.
5. The haematite schist is most in evidence near the richest copper ore body, while haematitic slate and slate are progressively less in evidence. The haematite fragments have a metasomatic origin.
6. The Red Hills copper body is a tabular anticlinal structure structurally conformable below the Owen Conglomerate. It is a bed of almost pure massive chlorite with some pyrite and chalcopyrite. It is a metamorphosed stratum, probably a pelite.
7. The stratum for 300 ft. below the ore body is a barely recognisable conglomeratic sediment which has been altered to a feldspar porphyry or syenite.

THE GOOSENECK

One mile south-west of the last exposure a coarse basal conglomerate is found containing large (12 inch) boulders of quartz porphyry. The base is not seen, but in the vicinity lies a vast quartz porphyry body which follows under the Owen Conglomerate. The evidence for unconformity is good, but the massive porphyry is unusual in that it is sometimes bedded and carries palimpsest pebbles.

NORTH END OF MT. TYNDALL

Where the power line and Dora tram intersect, the Owen Conglomerate seems to pass downwards into sub-greywacke sediments. Lenses of every size, from one inch upwards, of small quartz pebbles are found in the fine grained greywackes. The beds are commonly slumped and the lenses of quartz pebbles contorted. Immediately at hand, but overthrust on to these rocks, are beds of conglomeratic quartz porphyry.

About one mile east of the latter exposure, where Newton Creek penetrates the Tyndall Range, the base of the Owen Conglomerate is exposed over a wide area. There is the same transition into sub-greywacke as in the previous example.

LAKE DORA

On the high ridge 40 chains west of the middle of the lake is an exposure of the Jukes Breccia which is coarse, 50 ft. thick and very similar to that at Red Hills. The transition here is as conformable but not so abrupt, and quartz pebbles up to 9 inches long begin to occur in the underlying strata 50 ft. below the contact. The rocks in this zone bear haematite as pebbles, as disseminated crystals, and in quartz haematitic veins. The strata 200 ft. below, carry, as at Murchison, a massive chlorite bed about 150 ft. thick; this bears pyritic ore in a dissemination of microscopic grains. Underlying the ore bed is a thick sequence of " greywacke " beds with many conglomerate bands. Exposures are in the surface of large roches moutonnées along the shores of Lake Dora, and are very good but discontinuous. The rocks are made up of quartz porphyry pebbles set in much fine bedded matrix. They are immediately acceptable as normal sediments with unusually fresh looking pebbles. It is hoped to show the rocks were once greywacke conglomerates which have been porphyritised. This locality is chosen as the nameplace for the Dora Conglomerate.

MT. JUKES 3624/8075

The type section of Hills (1913) is very like those at Lake Dora and Red Hills. It has 60 ft. of coarse subangular breccia underlying the Owen Conglomerate and conformably overlying an observed 300 ft. of greywacke conglomerate. It is clear from Hills's thicknesses, and Hills and Carey's (1949) account that they have included these greywacke conglomerates in their " Jukes Breccia ".

UPPER LAKE JUKES 3622/8060

This section, continuous with the type section, is more accessibly exposed. The track to the lake crosses bedded greywacke conglomerates on the tarn shelf where they have been scoured by ice issuing from the

cirque. These greywackes are non-schistose rocks which show a halted process of feldspathisation. Pebbles and matrix alike contain porphyroblasts of feldspar and quartz. As the contact is approached, small quartz pebble bands are evident, and one would expect a transition into Owen Conglomerate. Instead, there is a zone of pyritisation and then the usual abrupt change into haematitic breccias. Despite faulting, the formations appear conformable.

SOUTH DARWIN PEAK 363/793

The map appended shows this peak as the down-faulted nose of a south plunging anticline.

The succession contains 40 ft. of Jukes Breccia, 200 ft. of conglomerate and 400 ft. of red quartzite with pebble bands. From the Peak towards the south-west the formation degenerates until, on the Clark River, it is only a 200 ft. thickness of quartzite. To the east and south-east it passes into thick calcareous shales, and the Tubicolar Sandstone alone is recognisable. The crucial exposure of this area is, however, that of the Jukes Breccia which, lying adjacent to the Darwin Granite, contains much haematite and granite pebbles. Hills has claimed that this exposure demonstrates an unconformity and a phase of Cambrian intrusion and mineralisation. For the sake of argument I will propose that the Darwin Granite is a granitised sediment and that the granite pebbles were formed in the contact zone in Devonian time. They were originally pebbles, of greywacke perhaps, which were altered to granite while other pebbles were replaced by haematite. The opposing views are conveniently called the granitisers' and magmatists' views.

The Jukes Breccia is fairly typical of the formation and consists of large 18-inch rounded boulders of granite, slabs of haematitic slate, many rounded pebbles of haematite, small fragments of a quartz chlorite rock (not schist) and small rounded pebbles of magnetite. An estimate of the proportions of ingredients is:—

Granite—2 to 18 inch pebbles	40%
Haematite—1 to 9 inch pebbles	30%
Haematite schist and slate fragments up to 12 inches long	5%
Quartz chlorite pebbles	15%
Magnetite pebbles	3%
Indefinable matrix with quartz, chlorite, and specular haematite	7%

About 100 ft. × 30 ft. of exposed breccias are seen in a low bluff. They stand in a vertical attitude and the granite appears to pass under this mass and to terminate it in a vague, undefinable fashion. The contact could be a weathered surface, but hardly a straight-forward unconformity. Again there might be a gradation of breccia into granite. It is the presence of magnetite above a fairly sharp surface which really defines the two bodies. The boulders of granite are perfectly fresh, unsheared and unschisted; they are clean cut and not at all diffuse; they weather out and fall to the ground. It is odd that, while quartz pebbles often have a blue-black rim of haematite, or further away have a pink suffusing of iron colouring, the granite is quite unstained. The structure is described later.

The Western Flank of the Main Anticline

MT. SORELL 3595/7950

This mountain, which is structurally an overturned anticline and syncline, presents three thicknesses of the lower beds to view in its eastern and vertical face. The western side of the mountain is a dip slope of Owen Conglomerate which consists of pink and white quartzites with strong conglomerates toward the base. The conglomerate bands are of relatively small pebbles, being rarely more than three inches and usually less than two inches across. The total thickness of the formation is 600 ft. to 700 ft., which diminishes southwards to only 200 ft. on the Clark River. The base is intensely haematite stained.

The lower portion of the eastern face of Mt. Sorell consists of 500 ft. of haematite-granite conglomerate. Though Hills called this the Jukes Breccia it is not a breccia, and is of much finer grain than any of the lower members of the Owen Conglomerate. Pebbles are, on the whole, well rounded and ellipsoidal and less than three inches long. They are in about equal proportions of haematite, a coarse quartz chlorite rock, and indisputable Darwin Granite. As it stands, these pebbles of granite, situated at least a mile away from the Darwin Granite mass, provide strong support to the magmatist view. The beds are probably in a position like those at Lake Dora and equivalent to the Dora Conglomerate. For the present they will be called the Sorell Conglomerate. It is unfortunate that the base of this stratum is covered by broad scree, for it is quite possible that if the Darwin Granite is sill-like it may extend under Mt. Sorell and so explain the Sorell Conglomerate as contact metamorphic rock. The presence of a coarse feldspar porphyry, not unlike some of the Darwin Granite, is demonstrable in the core of the Sorell anticline at Flannagans Flat. It is highly probable that this, or a variant of it, extends under Mt. Sorell.

CURRIE RIVER 3577/8036

Between Mt. Strahan and Mt. Darwin a lucky exposure reveals the full thickness of the Owen Conglomerate. Here, there is less than 300 ft. of vertically disposed strata which are cut through by a gorge of the superimposed Currie River. The Jukes Breccia is present and lies in contact with quartz chlorite schist of conglomeratic origin. About 100 ft. of coarse Owen Conglomerate overlies this and 150 ft. of quartzites complete the sequence. Forty chains downstream the Gordon Limestone overlies the quartzites. The Jukes Breccia, about one mile along the strike from the Sorell Conglomerate, contains no Darwin Granite.

MT. STRAHAN 3555/8050

The mountain has the structure of an asymmetric anticline overthrusting the sharp syncline of the Currie River. It is composed almost wholly of quartz sandstone and grit, but some underlying thin conglomerates are seen at Flannagans Flat Goldfield in the core of the fold. The contact is not well seen but is haematitised and pyritised, and the underlying rock is coarse feldspar porphyry. The total thickness of the Owen Conglomerate is 800 ft., and it appears that the formation becomes less conglomeratic from Mt. Sorell northwards.

KING RIVER GORGE 855/807

This difficult section occurs in a vertically walled gorge cut by the King River in steeply dipping quartzites. These are highly silicified, fine grained, red quartz sandstones with cross-bedding; they carry a few six-inch bands of quarter-inch quartz pebbles. It is difficult to tell the thickness as beds are repeated and the base is not seen; but 600 ft. of quartzites are known.

KING RIVER PACKBRIDGE 3577/8098

Below and to the west of the bridge about 20 ft. of conglomeratic greywacke occurs lying under limestone pug. The conglomerate contains small quartz pebbles to the extent of 30 per cent. This is not Owen Conglomerate as defined but is a facies of it.

LYNCH CREEK 3577/8149

At the King River-Lynch Creek confluence occur 10 ft. of fine grained, silicified, red quartz sandstones which immediately underlie the Gordon Limestone and are underlain by 15 ft. of greywacke conglomerate with small quartz pebbles. The greywackes peter out northwards, so that the quartzites and grits conformably overlie 200 ft. of varved yellow clays. This sequence is identifiable in several places further north.

SMELTERS RAILWAY 3604/8200

The railway cutting runs through much-faulted quartzose grits which have a sprinkling of greywacke pebbles and a sericitic matrix. There are 80 ft. of these grits underlying the Gordon Limestone. Despite intense chloritisation and kaolinisation these beds are clearly conformable on underlying greywacke conglomerates. The grits possibly lie outside the definition of the Owen Conglomerate, but are close to it. They are traceable northwards for a further forty chains.

SISTERS HILLS 3525/8250

The Owen Conglomerate consists of 150 ft. of fine grained sandstones and an underlying 150 ft. of conglomerate in which occasional quartz porphyry pebbles occur. There is no Jukes Breccia and the formation passes out by interdigitation with greywackes to the north-west. To the east the formation overlies thick yellow shales.

MT. MISERY. Road metal quarry, Zeehan Road.

The formation, 100 ft. thick, is dominantly of sandstones and coarse grits which conformably overlie red argillaceous greywacke sediments. The juncture is transitional and no breccias occur.

THE EASTERN FLANK OF THE ANTICLINE

Contacts along this limb are almost always intensely sheared and Owen Conglomerate lies against chloritic schist. The vertical conglomerate along the King Valley stands like a wall, and the formation diminishes in thickness southwards from 1,000 ft. at Crotty Smelters to 800 ft. on the Andrew River and less than 200 ft. at Darwin town.

DARWIN TOWN 3652/8000

The conglomerate for ten miles south of the town is of coarse grits between 100 ft. and 200 ft. thick. At Darwin it overlies very thick, fine greywacke grits and shales which are exposed on the mine foot-track. The contact appears conformable and the lower beds continue south for two miles, after which they pass into chloritic schists. South of the ten mile post the grits become finer and pass into Tubicolar Sandstone. Then a shaly limestone facies, like the Caroline Creek beds, becomes very prominent at the six mile post. The conglomerate is not recognised to the south of this point except as Tubicolar Sandstone or sandy limestone.

EAST OF THE SOPHIA-KING SYNCLINE

HAWKS CREEK

The conglomerate below the limestone is a fine grit 200 ft. thick. It rests on, or is "intruded" by, porphyritic granite. Both formations can be traced for several miles, and the granite, which is 300 ft. thick and a sill-like body, appears to pass under the Sophia syncline and to be continuous with the metamorphic granite and syenite in the Murchison Gorge. It is believed that the Hawks Creek granite is altered Dora Conglomerate, and it presumably rests unconformably on the adjacent Precambrian quartzites.

STICHT RANGE

The face of the range overlooking Anthony Creek consists of typical Owen Conglomerate with pebbles only two inches across. It is about 200 ft. thick and overlies intensely plicated quartzites. The latter are assumed to be Precambrian, for the reason that they most closely resemble known Precambrian strata of the centre of Tasmania.

ENGINEER RANGE

Here fine pink quartzites dip west below the Andrew syncline; they are less than 200 ft. thick and overlie plicated quartzites of Precambrian age.

THE OWEN CONGLOMERATE IN AREAS OUTSIDE OF THE WEST COAST RANGE

HOWTH

15 ft. of fine conglomerate and 10 ft. of Tubicolar Sandstone overlie slates. The contact has long been accepted as an unconformity.

TIM SHEA

The Owen Conglomerate overlies with a 60° unconformity the Precambrian dolomite of Tasmania. The contact was once a ravined and caved surface whose hollows, up to 100 ft. deep are filled with a breccia of dolomite which grades upwards by inclusion of quartz pebbles into conglomerate, and may be assessed at 200 ft. thick. The overlying quartz conglomerate is only about 100 ft. thick. It, in turn, is overlain by exceedingly finely bedded yellow to red quartzites. There are 200 ft. of these beds, then follow normal grits and fine conglomerates with porcel-

laneous chert fragments. These grits underlie the Caroline Creek beds at Tim Shea, and Mr. Banks informs me that the Caroline Creek beds, which are yellow shales, are passage beds of leached impure limestone. This exposure was shown to me by Professor S. W. Carey and the two succeeding descriptions have been recounted to me by him.

ADAMSFIELD

The conglomerate is 800 ft. thick, quite typical, and it unconformably overlies osmiridium-bearing serpentines. Elsewhere in Tasmania such bronzitites intrude Middle Cambrian formations. As the conglomerate is Tremadocian, Carey has thus shown the intrusion of the bronzitites to have occurred in later Cambrian time. The basal beds consist of serpentine detritus and the unconformity is marked by a placer of osmiridium.

ELLIOTT RANGE

The Owen Conglomerate which is less than 100 ft. thick rests with sharp angular unconformity on Precambrian quartzites. It is followed conformably by a great thickness of fossiliferous calcareous pyritic sandstones and shales (Caroline Creek Beds) which are followed conformably by Gordon Limestone.

LORINNA AREA

The conglomerate members of the Owen Conglomerate are not in evidence. Instead there is an enormous thickness, perhaps 1,500 ft., of the Tubicolar Sandstone. This is conformable below the Gordon Limestone.

LEVEN GORGE

The Conglomerate is 500 ft. thick. It overlies greywacke conglomerate and shales with abrupt change, but conformably and in well exposed section. There is no marked metamorphism at this point and the underlying strata are very similar to those at Mt. Misery.

MT. PROFESSOR

The whole formation is of quartzitic sandstones with grit and fine conglomerate bands.

MT. ZEEHAN

The conglomerate is 800 ft. thick and is similar to that of the West Coast Range. It unconformably overlies greywackes and lavas and thins out rapidly to the north of Zeehan where the Gordon Limestone rests directly on plicated quartzites of known Precambrian age.

THE DUNDAS GROUP AND PORPHYROID ROCKS

Underlying the Owen Conglomerate in the Range is a great thickness of greywacke sediments in various degrees of metamorphism. Recognisable formations have received local names such as Dundas Slates, Farrell Slates, and Read-Rosebery Volcanics. Recently Elliston, of the University of Tasmania, has analysed a 10,000 ft. sequence at Mt. Dundas, and proposed the name of "Dundas Group" for the collection of greywacke and volcanic formations there (this journal, p. 165). The term "por-

phyroid" refers in Tasmanian literature to a suite of metamorphosed porphyritic rocks, which are almost all Dundas Group strata. The users of the term applied it equally to sediments and "intrusives", whatever the nature and time of their origin. The general criterion applied was that the rocks were porphyroblastic or porphyritic. As the Cambrian greywackes are very susceptible to metamorphism it is natural that Dundas Group and Porphyroids should be almost synonymous, and that in general Porphyroids has had a stratigraphic significance. It will be shown that quite locally the Owen Conglomerate may also be changed to porphyry so that Porphyroids has no time or stratigraphic sense, and really refers to a metamorphic suite. Accounts of Dundas and Porphyroid rocks must always overlap, but they are treated separately in the following instance.

THE DUNDAS GROUP

Apart from the Dundas area, there is only one extensive and unbroken section of slightly altered older strata. That is the sequence on, and to either side of, Lynch Creek. About 10,000 ft. of strata are represented and three major divisions are clear:—

1. An upper formation which is dominantly conglomeratic. 3,000 ft.
2. A formation of lavas and lava breccias. 4,000 ft.
3. A formation of fine grained dense greywackes and slates. 3,000 ft.

It is proposed to call these the Lynch Conglomerate, Battery Volcanics, and Miners Slate Formations.

LYNCH CONGLOMERATE

This formation is best seen in timber tracks north of Lynch Creek (3584/8154). From the red quartzites at Lynch Creek bridge the sequence runs downwards:—

Quartz bearing greywacke grits	15 ft.
Varved yellow clays	200 ft.
Coarse subangular conglomerates	200 ft.
Alternations of finely laminated siltstone and fine conglomerate	1,000 ft.
Coarse conglomerates	250 ft.
Alternations of siltstone and fine conglomerates	1,200 ft.

The coarser conglomerates consist largely of lava boulders derived from the underlying formation, and smaller pebbles of lava are very common throughout the formation. The finest conglomerates consist, however, mainly of slate and greywacke pebbles, and the pebbles are only one inch across and well-rounded. The siltstones show a markedly rhythmic banding. The formation dips west at 40°, and participates in all the folds of the overlying strata. There is no hint of unconformity between Gordon Limestone and Lynch Conglomerate. For structural reasons it is believed that there is discordance somewhere between the Lynch Conglomerate and the Miners Slate. The lavas are so obscure because of weathering, and by their irregular habit, that it is impossible to observe unconformity above or below them. The presence of lava breccias and pebbles of lava in the Lynch Conglomerate suggests that earlier lavas had been elevated and eroded, but this evidence could almost as readily signify that there was contemporaneous subaerial

igneous activity in the neighbourhood. Erosion would not necessarily mean that orogenic movement had occurred but the presence of a very thick volcanic sequence does make it probable that some earth movement was taking place during Battery Volcanic times. Apart from these facts, there is no evidence to date an unconformity. Insofar as thick greywackes are characteristic of active orogenic belts, there is a distinct possibility that the Lynch Conglomerate contains repeated minor unconformities too small to show up in the crude structures which can be mapped. In total these unconformities might account for some of the discrepancies of dip between the Lynch Conglomerate and Miners Slate, but there is no way of assessing the degree of contemporaneous movements.

The one remaining piece of evidence on the relations of the Lynch Conglomrate lies in the attitudes of the formation as compared with those of the Gordon Limestone. The accuracy of mapping these two formations in detail is very low, but their strikes can be mapped for fully two miles in folded country, and any great discrepancy of dips and any great unconformity would show up under these circumstances. This is a small area to work with, but it is the largest intact piece of country available, and it does indicate conformity in the immediate area discussed here. In view of this conformity it is reasonable to include the Lynch Conglomerate in the Junee Group rather than in the Dundas Group of rocks, but the position of the lavas is left unsolved. It is suggested that these rocks be retained in the Dundas Group.

With this contention, the Lynch Conglomerate is a formation of greywacke sediments, predominantly conglomeratic, conformable below the Owen Conglomerate or the Gordon Limestone, and by inference unconformable on the Dundas Group or earlier sediments. It is analogous to the Dora Conglomerate.

THE BATTERY VOLCANICS

Proceeding upstream from the King Battery (3584/8146), the rocks met are augitic tuffs and spilitic lavas, deeply weathered and strikingly red in outcrop. The usual exposure is of vesicular lumps of lava in very weathered ochre. The vesicles are filled with dark-green chlorite which, because it does not weather further, gives a spotted appearance to the ochres.

The breccias are of heterogeneous, unsorted, angular fragments up to nine inches across. They are interbedded with subordinate greywacke conglomerates and shales. The formation was traced by asbestos seekers, who followed up veins of tremolite in the lavas. The tremolite is a normal alteration product of the augite in this vicinity. The diggings provide the few "fresh" samples of lava, which is an albite augite rock. The large extent of the lavas is indicated by the enormous amount of them in the associated and overlying conglomerates rather than by exposures of lava. There is a considerable variation in rock types from almost pure soda trachyte without augite to pyroxene rich spilites. The formation is difficult to define because of lack of knowledge but would seem to be of subaerial lavas and breccias of the keratophyre-spilite suite as defined by Wells (1922). It conformably overlies the Miners Slate and is overlain by the Lynch Conglomerate. By correlation with the Dundas area its age is considered to be Upper Middle Cambrian.

THE MINERS SLATE 3593/8145

This formation, exposed on Lynch Creek, is a hard, tough rock. Typically it is of dense greywacke siltstones hornfelsed or minutely recrystallised. It is not strictly a slate as it is not cleavable but only strongly sheared, and bedding is distinct. The formation, which is 3,000 ft. thick, has a well defined top but no recognisable base. Near the top it is dark-grey and fine grained, but lower down it is light-grey; particles become visible and the rock may be tuffaceous. There is often clear laminated bedding, and individual bands show tiny cross-bedding. Larger sedimentary features are absent except for the fantastic slump structures seen at 3631/8148, away from this section. That is a concertina-like folding which is restricted to the inside of bands one foot thick. The sediments are typical of a young, greywacke, phase of a geosyncline and the rhythms and slumping typical of redeposition in macigno facies. (Kuenen and Migliorini, 1950.) The formation is divided into three parts by interspersed breccias and lavas. It is represented in the topography by a ridge which is often split by erosion of the softer materials. This ridge, which often carries small mineral showings, is locally called the Miners Ridge, and it is from this that the formation name is taken. The slate forms a highly positive feature which, though broken at Queenstown, can be traced the rest of the way to Dundas. The base of the formation passes downwards into porphyries which may represent an underlying set of volcanics, but are really undefinable as other than porphyry. The formation can only be dated by analogy with the slates at Dundas which Opik (1951) dates as Upper Middle Cambrian.

Parts of the Lynch Creek sequence are readily identified elsewhere. The thick yellow shales near the Henty Bridge, 3533/2780, and the laminated shales at the Smelters are closely similar, and it is probable that they, the Lynch Creek varves and the red and green shales at Mt. Misery, are continuous. The greywacke conglomerates which occupy the area west of the Zeehan Road, between the Henty River and Pearl Creek, are all Lynch Conglomerate. Those beds become finer northwards, but, unlike the strata they pass into at 3505/8300, they contain no chert pebble bands. The Miners Slate is recognised on Reservoir Creek, in the middle of quartz porphyries on Conglomerate Creek, at the lower Power Station on the Yolande River, and alongside the Langdon River. Battery Volcanics and Lynch Conglomerate are met in a complex arrangement along the Comstock tram, with a good example of soda trachyte occurring in a bluff on the west bank of the river near Bridge 21, 3613/8242.

THE PORPHYROIDS

Twelvetrees and Petterd (1898, p. 43), referred some of the altered rocks from Mt. Read to Rosenbusch, who compared them with altered keratophyres of Thuringia and Wales and gave them the name porphyroid. This name has been freely used by the Geological Survey and was defined by Twelvetrees (1902), who stated that "a porphyroid is a dynamically altered quartz porphyry" and added that "the term can be applied to all the rocks of the porphyry complex". Tyrell (1930) gives the same impression of porphyroid, as a mylonitised and banded rock in which feldspar and quartz phenocrysts have escaped smashing. A. Holmes

(1920), attributing the term to Lossen, describes porphyroids in terms which best apply to Tasmania, that it, as " porphyroblastic metamorphic rocks intermediate structurally between halleflinta and granite gneiss ".

If the Tasmanian Porphyroids are typical of porphyroids elsewhere, and they seem to be so, then the mylonitisation of Tyrrell and dynamic metamorphism of Twelvetrees are misinterpretations of relict bedding or relict cleavage. Such impressions are readily understood on examining sections of porphyroblastic fine grained greywacke, or of sheared material which has recrystallised. It may be that Tasmania is exceptional in that rocks are wholly reconstituted without dynamic stress participating.

GRADATIONAL METAMORPHISM IN GREYWACKE FORMATIONS

SOUTH QUEENSTOWN

The Porphyroids are best studied in the area between Lynch and Roaring Meg creeks. Along the latter creek there is an exposure over a mile wide of quartz porphyry, and on Lynch Creek is the section just described. The Miners Slate continues from Lynch Creek through the quartz porphyry and provides an excellent marker bed. The lavas and conglomerates show a progressive alteration from south to north and pass into the porphyry. The first noticeable difference is the growth of small albite crystals which are red, and then a growth of larger pale crystals of oligoclase. The second stage is accompanied by much veining by epidote and speckling with pyrite. Next there is a growth of clear glassy quartz which forms a distinct rock type—quartz feldspar porphyry; the feldspars are up to a quarter inch across and quite sharp. The succeeding stage is relatively sudden, and feldspars are altered largely to sericite and their role taken by large quartz crystals, often milky with inclusions. An unusual phenomenon is apparent to the unaided eye in the beds which are well exposed in low bluffs at 3588/8165. The replacement of pebbles is selective, so that individual pebbles in a green augitic and tuffaceous breccia are the first to develop pink feldspars and the first to be quartzified. The margins of the pebbles are not sharp but diffuse. They appear to have reacted with surrounding rock and grown into it rather than to have reacted with outside solutions. No doubt both agencies were involved and were complementary. At first sight the fragments appear to be partly assimilated pebbles caught up in a lava, but the palimpsest pebbles constitute the entire rock, and the bed itself can be traced along its strike into normal breccias or conglomerate. The ultimate result of this process is best seen at a point, 3614/8251, 100 ft. above the Zig-Zag on the Comstock tram. At that point weathered surfaces show the rock as greywacke conglomerate, but on smashing, it is seen to be a uniform feldspar porphyry throughout. The same locality provides excellent examples, in blasted boulders on the railway side, of the intermediate stages of alteration to quartz porphyry. The pebbles, of which some portions now remain, were a pale chert at one stage, and in a process of outward growth have lost their identity. It is seen that crudely concentric growths of crystals when they extended to three inches across, merged into a homogeneous solid mass of quartz porphyry. There are many variations on this theme. Sometimes the centres of pebbles become void and are lined with epidote and red feldspar and sometimes calcite and galena fill the cavity (3569/8238).

The kind of diffused alteration described is not so general as a kind of metamorphism which results in a pebbly mass with very clear relict structures. Palimpsests are more distinct, for some reason, in the feldspar porphyries than in quartz porphyries. This may be connected with the process of formation; the quartz and feldspar are sometimes formed with only a slight lag between feldspar and quartz growths, but sometimes a rock is converted entirely to feldspar porphyry and only then to quartz porphyry; these latter rocks preserve palimpsests best.

Of course, the change from dark-green greywacke or lava to red or pink feldspar rocks is accompanied by loss of ferromagnesian minerals and by a change of augite through chlorite stages. Intermediate amphibole, tremolite, stages are very rare, and the common ferromagnesian mineral of the porphyroids is chlorite. The reaction of slaty or fine grained greywacke in this environment is odd. There seems no tangible reason, apart from texture, why these rocks should appear unaltered long after others have become unrecognisable. It happens that whole beds of such hornfelses run into porphyries, and even through granite, with very little alteration. Where such hornfelses have been brecciated prior to granitising the quartz porphyry replaces along the fissures and the porphyry appears to have a vast proportion of fragments in it. Such inclusions are common enough in quartz porphyries elsewhere and are sometimes interpreted as intrusion breccias, but these are clearly residuals. Unfortunately, the smashing of the country rarely allows the tracing of gradational processes along strikes, and work proceeds by observing at one point and applying at another until a complete picture is built up. The final argument rests in the consistency of the structural and metamorphic pictures established, and to a large extent in the consistency between this and other examples in literature.

Tasmanian literature contains many references to keratophyres and intrusive keratophyres and felsites. Although Ward (1908) located a lava at Tullah, and Waller (1904) mapped spilites at Zeehan, no other lavas are detailed anywhere. Similarly, there are numerous broad mentions of intrusive felsites, but only one mention (Gregory, 1905), of an "intrusive" contact. Microscopically, the felsitic rocks are very similar to intrusive felsites such as those of the Tertiary complexes of Scotland, and that is the only evidence for their intrusive character. Describing the Battery Volcanics and Lynch Conglomerate, Twelvetrees (1901, p. 29), finds that "microscopical examinations shows" it "to be an augite syenite porphyry"; "*Segregations of quartz much resembling pebbles have been taken for foreign inclusions*"; and "*the appearance of the pseudo pebbles is deceptive*"*. This appeal to the microscope blinded the vision of many, but not all, investigators. Some, including Ward (1908), who remarks on the "insensible gradation from felsite into feldspar porphyry and quartz porphyry", and Hills (1927, p. 2) regarded the Lyell Schists as metamorphosed igneous breccias. Waller has remarked to me personally on the puzzling appearance of "intruded" blocks of porphyry in slate where intrusion was out of the question and replacement alone was possible.

* All italics in this work are the author's

Acceptance of microscopical evidence was the rule of that time. In England, in the Lake District in 1875, Clifton Ward had described the Tasmanian type of phenomena excellently, pointing out the *differential replacement of coarse ash pebbles which " at a distance from the granite puts on more of the appearance of granite than does fine ash close to the granite "*. With the aid of the microscope, Green found this a strange old-fashioned view. Hatch is less ungenerous. Ironically enough, Ward also described Harker's classic Carrock Fell Gabbro as metamorphosed lavas.

In Tasmania, as in the Lake District, the magmatist has a problem; when conglomerates have a porphyritic matrix it is necessary to call the rock a brecciated lava or intrusion breccia, and when bedded rocks become feldspathised they are keratophyres, banded porphyries and felsites. So far there are no nodular or banded rhyolites, but I think that some of the conglomerates at Red Hills would pass for nodular keratophyre.

In the Range there are few exposures of unaltered keratophyric lavas, and it is thought that they were never extensive. The augitic lavas are much more frequently identifiable and of much greater extent. The best localities for keratophyre exposures are between the one and two mile posts of the Tullah tram, i.e., from Farrell Junction; on the Tullah track one mile from Rosebery; and on the Comstock tram. The areas of spilitic lavas include extensive tracts west of Zeehan, above the slates of Dundas, and on Lynch Creek as well as on the Tullah tram and track.

Intrusive phenomena of the felsites such as dykes, are not demonstrable, but some of the marginal phenomena of the quartz porphyries, on Roaring Meg and Cusick creeks, appear to be intrusive at first sight, i.e., lit-par-lit.

It is even probable that in the large structureless bodies of Mt. Read there were intrusive bodies of keratophyre comagmatic with the lavas, but they can only be hypothesised. On the other hand, there are no demonstrable lavas of quartz keratophyre anywhere, and it is probable that any similar intrusive rocks have had their quartz introduced after consolidation.

Apart from the Lake District and Tasmania, the porphyroid metamorphism of greywacke conglomerates and spilites is widely recognised. In Ontario, Holmes (1944, p. 1116) recognises a process by which " *conglomerates are metamorphosed to porphyry while fine grained greywackes are not* ". Goodspeed (1937) and Evans (1944) speak also of *selective replacement of pebbles by porphyry*. There are many such cases where the phenomenon has been recognised, but many more where rocks have been described and the process of replacement has not been recognised. Consider the Tregidden Conglomerates, which are associated with spilites in Cornwall; Flett (1946, p. 154) remarks on the odd feature of feldspar phenocrysts in the matrix of conglomerates. The crystals make it appear that the finer particles of sand were actually deposited as whole crystals. That phenomenon is common in Tasmania, particularly in the Red Hills feldspar porphyries. At Porcupine, Evans (1944) has used phenocrysts in matrix as the feature which distinguishes a porphyritised conglomerate.

He also remarks on finding mineral grains running from one pebble into its neighbour. In the West Coast Range this criterion, in hand specimen, is only applicable to the feldspar porphyry at the Zig-Zag. I have little doubt that the phenomenon of porphyritising is a common event in the history of geosynclines. Having seen the nodular rhyolites which form the base of the Borrowdale Volcanics in the Lake District, I should call them porphyritised conglomerates. If other nodular rhyolites of the Caledonian geosyncline are similar, then the process of porphyritising must be very common indeed.

MURCHISON RIVER

The example described at South Queenstown is only excelled by the exposures at Mt. Farrell. The rocks involved include the whole Dundas sequence. The lavas and breccias along the Tullah tram appear little altered, but are followed at the Mackintosh Bridge by syenite porphyries. About 150 yards upstream from the bridge are remarkable grey feldspar porphyries with very distinct bedding and lamination. The grain size is one-eighth of an inch, and apart from a little chlorite only feldspar is present. At the Murchison Gorge occur the Farrell Slates, very similar to the Miners Slates but with quartz pebble bands. They are followed above by chloritic breccias which, it was mentioned earlier, include syenites. Further upstream the syenites become progressively coarser and grow coarse biotite and feldspar porphyroblasts. The rock is clotted with all kinds of fragments and has no definable boundary against the schistose breccias. The margins are chloritised and pyritised. Pyrite, haematite, quartz and chalcopyrite appear in veins running into the Owen Conglomerate. About two miles upstream from the entrance to the gorge the syenite gives way to a porphyritic granite, whose relation to the conglomerate is like that of the syenite. The granite is still clotted, but with fewer fragments than before. The large pink feldspars are of orthoclase. The granite sill, mentioned earlier, on the far side of the Sophia Syncline, has been traced in a similar position below the Owen Conglomerate to within a mile of the Murchison granite. The two rocks are of the same biotite granite, and the probability is that the "sills" are continuous and all of metamorphosed greywacke sediments. From the Murchison River the granite passes west over the north end of Mt. Murchison into quartz porphyry, then feldspar porphyry. Everywhere this stratum preserves a structural position overlying the Farrell Slates; it is certainly a tabular body, certainly a metamorphosed sedimentary formation, and it occupies the position of the Dora Conglomerate.

PORPHYRIES WITH CONCORDANT CONTACTS

RED HILLS

The porphyry contacts at Red Hills and Lake Dora have been described. At Red Hills the porphyries show the following descending sequence:—

Jukes Breccia with haematite replacements	50 ft.
Feldspar porphyry = greywacke conglomerate	150 ft.
Massive chlorite, pyrite beds	150 ft.
Feldspar porphyry, massive with conglomeratic bands—	200 yards across
Quartz porphyry with occasional pebbles —	50 yards across
Fault zone of schistose porphyry and chlorite sericite schist.	
Massive quartz porphyries.	

In this area there can be no question that the rocks are metamorphic, nor that they are typical quartz porphyry or feldspar porphyry. The rocks have a rusty colour on weathering, and in fresh specimens the quartz porphyry has a reddish-brown or purple colour. The fresh feldspar porphyry is pink, has orthophyric texture, and an even grain size of 2 mm. There are all grades from feldspar porphyry (felsites of earlier writers) through a rock with tiny clear quartzes, to the quartz porphyry which is studded with phenocrysts up to 1 cm.

At Lake Dora there is even less possibility of confusion on the original constitution of the rocks. There, they are so patently conglomeratic and bedded that they would not normally be regarded as metamorphosed. Some bands near the Lake are highly altered, however, and the general sequence is the same as that at Red Hills. In both areas the original conglomerates were well bedded but not well graded. Their pebbles run up to 3 inches across, are well rounded, and are set in much fine matrix which is now porphyroblastic.

MT. SEDGWICK

The rocks of the Mt. Sedgwick Dome are conglomeratic quartz porphyries with thin hornfels bands. They are identified with the Dora Conglomerate and consist of coarse pebble beds whose diffuse margins fail to separate them from massive porphyry. The pebbles are exclusively of porphyry, and at first sight it appears that they are derived from, and deposited on, the massive rock. This view is not tenable, because the massive rock and pebble beds are interbedded, nor can it be allowed that the "igneous" rock is intruded; apart from the vague contacts and coarseness of the porphyry, the structure would demand three phases of intrusion and of erosion; each erosion should produce a conglomerate and each conglomerate should be almost exclusively of porphyry pebbles. The bedding of the porphyries is conformable with that of the Owen Conglomerate, but the juncture of the formations is oblique to bedding, for it lies below the Jukes Breccia at 364/828 and below the Red Quartzite at 3645/8255. All contacts are haematitised.

MT. LYELL, 3660/8220, AND LITTLE OWEN, 3665/8180

The Dora Conglomerate in these areas is similar to that in the last, except that on Mt. Lyell it is slightly schistose and its pebbles are drawn out a little in the vicinity of the North Lyell Fault. The Dora Conglomerate pebbles, on the whole, are coarse—up to six inches across; they are tabular, elongate and ellipsoidal, and are fairly well rounded. There is no doubt that they underlie the Owen Conglomerate, and they do so conformably. The rocks show quite sufficient of the bedding, much of it on aerial photographs, to compare the structures above and below the contact line. Both formations form low domes which are concentric. The contact line below Lyell Peak lies below the Jukes Breccia, which is haematitic, but following it to the east the contact passes from bottom to top of the Owen Formation, until at 3687/8228 only the uppermost sandstones of the formation overlie quartz porphyry. The same happens above the railway on Little Owen where it is more accessible. There the conglomerates are down to 300 ft. thick and almost the full thickness can be seen in the cliffs. The contact

stratum there is the blue haematite stained " Red " Quartzite. Unhappily in view of the known sedimentary variation of the Owen Conglomerate, these changes of horizon are almost useless for demonstrating discordance of contacts.

PORPHYRIES WITH PROVEN DISCORDANT CONTACTS

Regional metamorphism in the traditional sense does not allow for this kind of situation to be described; that is, that quartzites might alter abruptly and, within an inch, be replaced wholly by feldspar porphyry. Classic metamorphism allows only a restricted diffusion of material, but in porphyroid metasomatism there is complete freedom of migration within clear cut zones. The absence of dynamic stress phenomena is the second great difference between porphyroid and " regional " metamorphism. Although there are excellent descriptions of gradual alteration of quartzites in the work of Reid (1945), Quirke and Collins (1930) in Canada, and Ellis (1947) in South Africa, only Perrin and Roubault (1942) in France describes an abrupt metamorphic boundary quite similar to that at the Lyell Mines.

MT. LYELL-COMSTOCK MINE

The eastern side of the open cut shows vertical quartzites which, passing downward, have an indefinable margin against sericite schist. The massive structures of the schist and quartzite are continuous, and the margin between the two is a diffuse irregular zone. Continuing downward, the schists are completely replaced by a mass of pyrite, which has a knife edge contact with schist. There are two stages of replacement—one of quartz by sericite and one of sericite by pyrite. Because the latter is commonplace, and because we think of sulphides as " mobile ", it is readily conceivable that pyrite replaces sericite. Because we usually think of sericite as resulting from the alteration of chemically similar feldspar, without a vast change in composition, it is difficult to believe that quartz can " change " to sericite. In fact, the quartz is not " changed " but is removed, and sericite takes its place. The contact is such that sericite penetrates the shaly layers between quartzite bands in the manner of lit-par-lit " injections ", and that red quartzite fades to pale-yellow and then disappears into coarse, almost pure, sericite. The latter change takes place in a distance of less than two inches. The only direct evidence that the schists are altered quartzites lies in the residual bedding which occurs, and which can be traced across the contact. Neither microscope nor chemical analysis can demonstrate that this change occurs, half as well as can the naked eye; complete reliance must be placed on recognising the residual structures and on the interpretation of the shapes of contacts.

MT. LYELL MINES

The Lyell structure has been described by Conolly (1947) as resulting from the intersection of a monocline with smaller folds. Along the resulting upturned margin of the Owen Conglomerate a metamorphic contact occurs. On the one side are quartzites, and on the other schists. Chlorite and sericite are the predominant minerals of the schists, in which schistosity is not regionally oriented but is parallel to local faults and shears. The schists appear to be Owen Conglomerate which has been

bodily replaced by feldspar, sericite, chlorite and pyrite. The schists, Mt. Lyell Schist of Hills and Gregory, are green to rusty looking rocks which do not fit into any recognised category. They vary considerably from the pale-yellow sericite, or paragonite, schists of the Old Blow to massive unschisted chlorite rocks. In the low grade ore which is, like the other bodies at Dora and Darwin, a stratum, the rock contains much sericite as well as pyrite and chlorite. Although pyrite is only just discernible in the ore it is easily seen in stream sections below the North Lyell Ridge. The rocks frequently show a banding which has consistent strikes, and frequently the schist is nodular or lumpy as if it were, in fact, altered conglomerate. This banding agrees with the disposition of the Owen Conglomerate of the North Lyell Ridge and with that across the contact. When strata on both sides of the contact are mapped on the supposition that they are continuous, a consistent picture of structures is obtained. Of minor structures, the white rectangular flecks in the schist are interesting. Though now wholly of sericite these indicate that the schistose conglomerate once passed through a feldspathising stage.

The shape of the contact is only less complex than those of lit-par-lit intrusion surfaces. It led Gregory (1905), Edwards (1943) and Nye (see Edwards) to believe the schists were altered intrusive porphyries. The contact wanders erratically from the Tubicolar Sandstone down to 1,200 ft. underground, and Conolly, from mine surveys, finds that the Owen Conglomerate and the schist interpenetrate as though the schist had replaced individual beds.

Both Conolly and I, independently, have traced palimpsest features of the schists, and can demonstrate the continuity of beds and folds across the contact line. Only rarely is it possible to trace beds through the contact zone because of the local intense metamorphism.

On the outside of the contact surface is a zone of conglomerates which are made up very largely of hard blue haematite pebbles. The possible origin of these pebbles is debatable, and their true interpretation of utmost importance. Hills contended that they indicated unconformity and were derived from pre-existing Cambrian deposits. Dr. Opik has suggested to me that they might be of lateritic origin—I contend they are of metasomatic origin. The "facts" are as follows:—

1. The pebbles are clean cut.
2. The pebbles are mixed with quartz pebbles over some 50 ft. from contacts, but are most numerous and almost exclusive near the contacts.
3. Pebbles occur to a depth of six inches alongside sericite veins which cut the bedding of normal quartz conglomerate.
4. The contact and haematite pebble zones run vertically through the 1,200 ft. of the conglomerates.
5. Despite 4, no haematite pebbles occur elsewhere as bands in the conglomerates.

Looking at the regional picture we find:—

6. The haematite pebbles are most numerous when close to mineralised faults and copper ore bodies of Devonian age. This applies all over western Tasmania—Mt. Balfour, Mt. Darwin, and Dial Range.
7. In the cases where porphyry-Owen Conglomerate contacts are concordant the haematite occurs only at the contact and neither below nor above.

8. The slab-like haematite schist of the Jukes Breccia was not transported in that condition because it is friable, nor was it "schisted" *in situ*, because the neighbouring haematite pebbles are massive. The specular haematite has grown *in situ* and adopted the lineation of random slabs of slate.
9. Where the Owen Conglomerate is in contact with little altered greywacke, as on Newton Creek, not only are there no haematite pebbles, but the whole formation is almost unstained and white.

It is hardly necessary to add that the proposed sources of haematite are hypothetical.

Allowing that the pebbles are metasomatic in origin it follows that all of the "underlying" rocks are probably metasomatised. That means that, among others, the innocent looking porphyry conglomerates at Lake Dora are reasonably interpreted as metamorphosed. More important still is the inference that, as the pebbles of haematite are replacements of individual pebbles, rather than of the rock as a whole, the original conglomerate must have had varied constituents. Considering only that section at Lyell, it is clear that as the Owen Conglomerate was all quartz or quartzite, the differential replacement is attributable to the texture of the pebbles. By a process of elimination it appears that the quartz schist is the first type to be replaced, perhaps because of the straining and raggedness of its crystals. Vein quartz goes next and quartz sandstone last. Replacement of the Owen Conglomerate by sericite follows the same order, which is probably an order of decreasing energy content of crystals.

On the outside of the contact line there are many hundreds of small quartz veins which peter out upwards, but which end abruptly downwards against the schist. It appears that the formation of these veins and the silicification of the Owen Conglomerate represent a front of silicification overlapped by one of haematitising. It is thought that the overlapping silica-haematite fronts are relatively low temperature phenomena which, in less intensely mineralised areas, are represented by a single zone of jasperising. The different crystallinity in these contacts is probably a function of volatiles present. This outer zone of silicification is not to be confused with Reynolds's (1946) front of silicification, which is a higher temperature phenomenon. To avoid confusion it is best to speak of a zone of jasperising.

At Lyell there is a second and much later phase of low temperature silicification associated with late north-east veins. It cuts porphyroids and quartzites alike and is not a zonal phenomenon. The silica of these veins is cherty and never coarse; it results in the silicification of the schists which Gregory (1905) and Hills (1927) remark on at North Lyell and Conolly notes at Comstock. Two phases of silicification of the Owen Conglomerate make it difficult to assess either of them accurately.

The conglomerate-schist contact surface is a relatively thin zone, being rarely more than twelve inches, and often only one inch, across. It is imagined as having been an isothermal surface of a critical kind, perhaps at the critical temperature of water. At favourable points round the North Lyell Ridge (3627/8220), the gradation of quartz conglomerate to quartz sericite schist is observable. The change is complete in six

inches; the pebbles first become loose as the matrix is replaced by sericite, the red stain of haematite changes to green or yellow and the lustre of quartz is replaced by a dull porcellaneous appearance. The succeeding stage, when the pebbles are wholly replaced by sericite and chlorite, is sudden. The change is preferential, the sandstone bands being the last to alter. Near the Blow they are left as ragged blocks deep in the schist (3629/8204). Sometimes the Red Quartzites and associated pebble beds are left as a broad ridge or band interdigitating with schists. This is the nature of the North Lyell Ridge.

Unfortunately, the haematite zone usually masks other processes, but it appears that both sericite and haematite have replaced quartz pebbles. It also happens that feldspar porphyry has replaced quartz pebbles, but this is rarely clear because the feldspar porphyries are themselves replaced by sericite chlorite schist. Most of the schists originated in this way, which is why Nye, in Edwards (1943), described them as altered intrusive porphyries. Such sericitising of feldspars must be regarded as a retrograde process. While a well defined zone of sericitising is common there are places, on granite contacts, where it is missing and in many cases sericitising is clearly a late phenomenon and is not zonal. The chloritising is associated with sericitising to a considerable extent but is often independent. I believe that chloritising is fundamentally zonal and that it coincides with a zone of pyritising. This zone is very clear indeed and, very oddly, it is usually inside the zone of feldspathising. At Lake Dora, Red Hills, Lake Jukes, Darwin, and West Lyell the sequence runs:—Quartzite, haematite, feldspar porphyry, chlorite, feldspar porphyry, quartz porphyry (or schistose varieties of these). I imagine that the arrangement is accidental, dependent on the nature of the original rocks, and that the chlorite zone can be regarded as following that of haematite. It is conceived that the zone of chlorite and pyrite does not move forward smoothly but proceeds in distinct steps from one suitable host to the next. On the small scale that principle is implied by the selective replacement of pebbles by haematite.

SNAKE SPUR 3637/7997

The red quartzite cliffs overlooking the long-derelict Darwin town are of slightly dipping Tubicolar Sandstone 200 ft. thick. That is a dense, current bedded, fine grained silicified rock which overlies schisted feldspar porphyry. 300 ft. below lies the structurally conformable low grade ore, a tabular body of sericite, chlorite, pyrite schist. The quartzite is blue with haematite; it contains rectangular sericite chlorite pseudomorphs of feldspar and grades into the feldspar porphyry of Darwin Peak. The evidence clearly indicates the following replacements: quartz to haematite, quartz and haematite to feldspar, quartz and feldspar to sericite and chlorite.

LATE PROCESSES

QUEENSTOWN 3597/8184

It may be anticipated that any zoning of metamorphic processes which once existed must have been followed by processes consequent on cooling. One might expect to find retreating isogeotherms and, in a crude fashion, retreat of fronts; the unzoned and random processes

of retreat are analogous and similar to, and in some cases identical with, the late phases usually attributed to magmatism.

At Queenstown it is possible to study the effect of late processes which post-date the formation of the quartz porphyry there. The porphyry body south of the town has been completely leached by steam and reduced to a mass of china clay studded with quartz crystals. The adjacent Crotty Quartzite at the Sandhill has been deprived of any binding material it might have had and is now a heap of soft white sand. This leaching is most intense along the north-eastern fractures, and it is supposed that it is the silica lost in this process which is deposited higher up in the north-eastern vein system. It is probable that the gold and galena content of these veins has a similar derivation. Where north-east veins cut the low grade copper ores enrichments occur (see Conolly (1947)), and these are probably the result of leaching and redeposition. This is almost certainly true of the siliceous ores of Comstock and North Lyell, which are both late in origin. Where the augitic tuffs behind the Smelters (3604/8197) have been injected, the resultant rock is a dark-green clay consisting of kaolin and chlorite. This is the "fresh" rock of much of the country and it reveals its origin through the "ghosts" of breccia and lava fragments it contains. Where peat cover remains this green muck is preserved as "fresh" rock, but on exposure oxidation turns it into a limonitic clay whose livid rusty hue characterises the landscape.

It is emphasised that these processes of hydration, leaching and redeposition; of kaolinising, sericitising, silicifying, pyritising and chloritising, though similar to those existing on the outer fronts of metamorphism, are not zonal; they are late and retrograde.

SUMMARY OF ZONING

After allowing for late phase anomalies, the following system of zones is thought to exist in an ideal sequence:—

(*a*) Silicification. } Jasperising
(*b*) Haematitising. }
(*c*) Contact of schist-non schisted rocks. Barite common.
(*d*) Sericitising; desilicifying.
(*e*) Chloritising and pyritising; reduction of haematite to magnetite.
(*f*) Feldspathising.
(*g*) Feldspathising and epidotising.
(*h*) Introduction of potash as biotite and orthoclase.
(*i*) Introduction of quartz.

This scheme will be developed in Part II.

Some endorsement of the sequence is obtained from Dunham who, contributing to Reynolds (1946), suggests that the zone of haematite at the copper mines at Butte is a front of desilicification; from Lapadu Hargues (1948A and B), who proposes a front of mineralising and reduction; and from Leedal (1952) who describes the metasomatic replacement of quartz by haematite and albite. A zoning of chlorite schist and jasper is very apparent in Miles's (1943) account of West Australian jaspers; the repeated association of gold and pyrite at such contacts is a world wide phenomenon.

The schist-jasper or pyrite-haematite contact is a most important metamorphic and economic index.

THE DARWIN GRANITE

This topic has been delayed while some principles were made clear at other less controversial places. The Darwin Granite is a metamorphic complex which occupies the plateau of Mt. Darwin in a rectangular outcrop. The granites occupy the core of an asymmetric anticline, and their strike, which is very obvious, is parallel to the anticlinal axis. At each end of the granite the anticlinal roof has been dropped and the body terminated. The granite margins to east and west are defined by their contacts with hornfelsed fine-grained greywacke beds and adinoles respectively. The granite is then either sill-like or like several sills with "concordant" walls. Hills has mapped a roof pendant which runs through the granite and which consists of sericite schist. Two more roof pendants have been mapped by myself, but these, while being a more distinct black hornfels, are not as long as the former. The granite consists of three broad bands of Darwin Granite, one of graphic granite and another of quartz porphyry. At the northern end of the body, just about on the fault line, the granite merges into quartz porphyry.

The granite itself is a coarse porphyritic rock identical in places with that on the Murchison River. It contains pink phenocrysts of feldspar with a green and white matrix of feldspar, chlorite, and quartz. The rock is quite hard and fresh and has not been subject to marked alteration, so that the chlorite is considered to be original. Biotite does occur as thick books, but sparingly and localised. The granite is a massive rock weathering into large blocky forms with few joints and no shear planes. It would make good building stone on this account, but the importance of lack of jointing lies in the fact that this granite (if we accept the evidence of unconformity), has been folded acutely. It must, also, have been sheared with some force at the exposure of the "unconformity"; sufficiently to create a sharp tear fault and rotation of pebbles in the overlying Owen Conglomerate. The granite is sheared neither in its mass nor in its pebbles. The granite is, by its form alone, metamorphic, and if further confirmation were needed it contains palimpsest pebbles which weathering has brought out very clearly at 3636/7946 (Plate I). These are not vague shapes; they are sufficiently clear to show the granite conglomerate to be made of large rounded ellipsoidal pebbles from six to nine inches long. They show no appearance of being drawn out and are arranged parallel to the strike of the other members of the complex.

The graphic granite occurs at 3636/7963 and is some forty yards wide. It is a white rock with fine-grained graphic intergrowth of quartz and feldspar. The quartz porphyry on the north and west of the plateau is the typical red rock of the region. The adinoles are the only example in the region of feldspar porphyroblasts growing to macroscopic size bedding, and are black with pink flecks and streaks. The complex can hardly be other than Dundas Group greywackes or Lynch Conglomerate, in fine grained greywacke. They have a somewhat wavy but not plicated

or both. A traverse across the granite on the creek at 3636/7963 shows the following cross section from east to west:—

Black fine grained greywacke hornfels	100 ft.
Darwin Granite	800 ft.
Black fine grained laminated greywacke hornfels	200 ft.
Darwin Granite	600 ft.
White Graphic Granite	120 ft.
Sericite schist	100 ft.
Darwin Granite grading into—	
Quartz Porphyry	600 ft.
Adinoles with magnetite veins	500 ft.

This shows no repetition which would demonstrate an anticline, and the thicknesses, which are based on the rocks being vertical, indicate a total of the order of 3,000 ft. It is unfortunate that only one area of contact with the breccias or conglomerates is seen. This is the vertical limb of the fold at South Darwin Peak (see below under Lyell Shear). Naturally, the fault which dropped the conglomerates and eliminated contacts could not eliminate the vertical limb so readily, and this remains on the north side of the fault. The breccia is vertically disposed and appears to face topside to the west. As the breccia lies on Hills's roof pendant, the structure requires that it, as well as the pendant, should pass into the granite. In a broad sense, then, the granite is discordant to the attitude of the breccia, but the evidence is not convincing.

There is only a very vague and worthless suggestion of gradation between the Jukes Breccia and granite. Some distance away (3617/7923) a small downfaulted block of Owen Conglomerate lies in contact with granite. The arrangement suggests that the granite, like the conglomerate, is tabular. At this contact the rocks are pyritised and sericitised, a feature absent from the first exposure, the Jukes Breccia is missing and the contact is parallel to bedding in the Owen Conglomerate. The presence of haematite and magnetite at the contact do not, especially in view of the reduction change at contacts, carry any weight for unconformity at this locality or on Mt. Sorell. The presence of granite pebbles carries a great weight, and in order to explain them in a granitising hypothesis it would be necessary to postulate that they were fragments of a rock similar to that from which the local granite was formed, and that they have been selectively replaced by feldspar and quartz. One must further propose that other pebbles have been replaced by haematite, and that some of these, low down in the contact zone, have been converted to magnetite. It is indisputable that the granite complex is a metamorphic one and the Darwin Granite a metamorphosed conglomerate. Inside the complex itself it is certain that beds of hornfels have not been replaced while other beds have been changed to Darwin Granite, graphic granite, or schist. Each has been differentially affected, and so clearly that contacts are very sharp. If one allows that this is true, and it is commonplace, then it is unreasonable not to allow that varied pebbles within fifty feet of the contact might be similarly affected.

The arguments now are that the contact represents a straightforward unconformity, or a metamorphosed unconformity between Jukes Braccia and Dundas Group rocks, or a metamorphosed juncture between conformable Jukes Breccia and Dora Conglomerate. The evidence of conformity elsewhere and the presence of "pebbles" in the granite suggests that the third case is the most probable of the three.

If one accepts the thesis of a Cambrian granite one must also accept that the Darwin Granite was formed *in situ* by metamorphism of conglomerates, and that it was granitised again in Devonian times. This would appear to require a lot of coincidence.

On the other hand, and viewing the wider problem of Jukes Breccia contacts, the granitiser must explain the presence of quartz porphyry pebbles in places like Red Hills, where the underlying rocks are feldspar porphyries. It happens that in such localities as Red Hills the Jukes Breccia, overlying pebbly feldspar porphyry, never contains feldspar porphyry pebbles. It will be contended, in Part II, that both the quartz porphyry and feldspar porphyry pebbles were originally greywacke, and that they have been differentially affected in the two zones of feldspathising and silicification.

Looking further afield there is very strong evidence on record to show that the granitising thesis is a possible one. The following examples are useful illustrations:—

(1) O. A. Jones (1947) reports on observations made by Professor Bryan and himself on a granite contact in Queensland, "in favour of the granite being intrusive":—

(*a*) The *granite is intruded as dykes into a conglomerate.*
(*b*) The strata end abruptly against granite.
(*c*) Shales appear baked.

and "in favour of it not being intruded":—

(*a*) *Granite pebbles appear in the conglomerate.*
(*b*) The granite contact is coarse.
(*c*) The granite clearly consists of boulders.

These observations had been previously made by several other geologists. The example clearly parallels the Darwin case and is well authenticated.

(2) The next example has to be compiled from reports on the Mesabi Range. Allison (1925, p. 500) finds that "*unmistakable fragments of it* [*the Embarrass granite*] *occur in the conglomerate* at the base of the Animikie series". The contact is described as having been weathered and later metamorphosed, and the overlying haematite pebbles are, of course, lateritic. In the opposite camp Richarz (1930, p. 611) finds, as did Leith, that the same granite is intrusive, and that "*pebbles of the overlying iron formation are partially encompassed by granite* and surrounded by a contact rim" (he imagined the haematite to be a prior deposit). He states (p. 609) that "an examination of stratigraphic conditions [meaning discordant relation] re-establishes beyond doubt the intrusive character of the granite", and that (p. 607) "feldspars grow from the granite into the sediment". Winchell, independently of all and supporting intrusion, is quoted by Richarz as saying "*the magnetic quartzite* [of the overlying formation] gradually becomes less highly charged with magnetite, acquires feldspathic and quartzose material, and finally *is changed into the syenite of the Giants Range*", i.e., the Embarrass Granite; and as observing "that the Animikie appears to be feldspathic in spots, as if there were boulders of syenite in it". In neighbouring

areas of the Giants Range everybody is happy about the unconformity with its haematite and granite boulders, but very puzzled about the source of the haematite of the pebbles. This is a highly authenticated example and the writers were discussing the same localities. The granite pebbles were fairly clear to some people, though apparently nothing like as clear as at Mt. Darwin. The parallel of the example, even down to the presence of pyrite and magnetite zones, is very clear, and if we consider the jaspers and haematite pebbles as silica and haematite zones there is a very marked parallelism. Winchell's example of gradation is very like that hypothesised for Mt. Darwin and his boulders of syenite are equivalent to boulders of granite at South Darwin.

(3) Goodspeed and Coombs (1937) give an excellent example of preferential replacement of boulders. They propose that in a cataclastic breccia certain *blocks of hornfels have been preferentially replaced by granodiorite,* while *other blocks, which were of the same material, have been left unaffected,* and explain the difference in reactivity of the two sets of fragments as due solely to a more sheared condition in the replaced blocks. Photographs show boulders of granodiorite with margins quite as sharp as those at Darwin Peak.

(4) Collins *et al.* (1926, pp. 11-32) describe a conglomerate sequence which runs from granite porphyry, through a conglomerate of granite porphyry boulders, and through pyritic, sideritic, haematitic and jasperoidal rocks into greenstones. *The unconformity cannot be delineated because the granite and granite boulders merge.* Moreover, the matrix of the conglomerate consists of sharp unweathered feldspars and quartz. Because of this it is deduced that conditions of formation of the conglomerate were most unusual. While it is deduced that there is an unconformity, the authors conclude that there is also a second granite which can be demonstrated to intrude the overlying strata. The two granites are so alike as to defy their separation in the field, and their *distinction rests solely on the distinction of unconformable and intrusive relations.* It is worth remarking that this is in a region where granitising of the gradational type of South Queenstown has been beautifully described (Quirke & Collins (1930)).

(5) Perrin and Roubault (1942) describe a type of metamorphism very similar to that proposed for the porphyroids of Tasmania. They propose that such metamorphism can terminate abruptly against non-metamorphosed rocks and they provide a wealth of detail to support this contention. They demonstrate that what has previously been widely accepted as an unconformity between Mesozoic strata and crystalline rocks is a metamorphic contact. They also give a number of references to similar phenomena.

(6) Kihlstedt (1948, pp. 425-553), describes the occurrence in the Phillipines of magnetite and pyritic ores at the juncture of non-metamorphosed and regionally metamorphosed rocks. The lower rocks belong to the Miocene " Universal " formation, a sequence of basalts, andesites and sediments which have suffered intrusion by diorites and consequent " porphyroblastic " non dynamic metamorphism. Unconformably overlying this formation is the agglomeratic " Larap " formation. The ore zone is interpreted as lying along the unconformity which is also a line

of intense thrusting. The thrusts are associated with the early introduction of iron and a later phase of intrusion by syenite porphyry. This porphyry is reputed to intrude below the magnetite and by metasomatic fluids to convert the Larap agglomerates, above the unconformity, into a rock resembling aplite. This new rock has textures varying from massive, through agglomeratic, to conglomeratic [nodular syenite? J.B.]. The removal of dark minerals in these rocks occurs on fronts which may be from a "fraction of an inch to two inches wide".

The involved explanation requires that the magnetite ore has been thrust and brecciated and the "fragments rolled and rounded off to pebbles"; there has been thrusting, and two periods of intrusion, of extrusion, and of metamorphism. All of this is supposed to have happened since Miocene time.

To the writer it seems that the ores have been the result of granitising similar to that at Mt. Darwin. From these and several other examples there appears to be a common association of lines of thrusting with vulcanism, unconformity, tectonic and sedimentary breccias, metasomatic granitising and mineralisation.

Strong confirmation for the general thesis proposed for the porphyroids comes from Per Geijer (1910) in his account of the igneous rocks at Kiruna. His section, pp. 701-2 and text runs, for the upper portion.

1. Quartzitic sandstone and conglomerate.
2. Phyllite and greywacke with quartz porphyry and iron ore pebbles.
3. Barite and quartz haematite veins, silicified tuffs and sericite rocks with interstratified syenite porphyry. This zone is pyritic.
4. A narrow band of magnetite.
5. Quartz porphyry with agglomerate bands [replacement breccia? J.B.].

(N.B.—Barite veins are common at Lyell and Darwin.)

For comparison the writer has inverted the eastern half of the section thus:—

1. Sodic greenstones with tuff bands.
2. Kurravaara Conglomerate—tuffaceous.
3. Nodular syenite porphyries.
4. Recrystallised syenite.
5. Magnetite.
6. Quartz porphyry (No. 5 of the upper portion).

These sequences are very similar to the two types of metamorphism seen at Queenstown, i.e., the abrupt type against quartzites and the gradual type against spilites. The nodular character of the Kiruna syenites is celebrated.

These examples cannot be left without citing the alternative view put forward by Pettijohn (1949, pp. 259-60). Rocks which some observers have described as granitised he regards as recomposed granitic detritus. It is probable that his view is sometimes the correct one but it certainly does not apply to the porphyroid rocks of western Tasmania. The writer contends that his criteria of recomposition, all of which apply to the porphyroids in one place or other, are inexact or negative generalisations. They are almost useless for distinguishing between granitised and "recomposed" rocks.

Conclusion

The problem of the Darwin Granite is part of the problem of the porphyroids, that is, even if one chooses to adopt a thesis of two periods of granitising. The magmatists' difficulties in explaining the known phenomena are overwhelming in number in each of the fields of structure, lithology and sedimentation. To take a few examples of those difficulties; he must explain:—

1. Greywacke-porphyry transitions.
2. The restricted distributions of porphyry, granite and haematite pebbles.
3. The source of haematite pebbles.
4. The " roof pendants " of the Darwin Granite.
5. The variation of the composition of the granite.
6. The " pebble " character of the granite.
7. The unsheared nature of granite and granite pebbles.
8. The absence of dykes.
9. The phenocrystic matrices of conglomerates.
10. The coarseness of granite and porphyry contacts.

The thesis outlined above is structurally, lithologically and historically consistent, and though the propositions are novel they are fundamentally simple. Field evidence here and elsewhere supports the general contention of a metamorphic boundary.

While it is thought that the evidence for an intrusive phase in the Cambrian has been negatived, it is still probable that an unconformity exists between the Darwin Granite (Dora Conglomerate) and the adinoles (Dundas Group Slates) at Mt. Darwin.

Finally, there are the problems of nomenclature of porphyroids and of the Dundas strata. It is proposed that the Dora, Lynch and Sorell Conglomerates be identified as one and be called the Dora Conglomerate, and that this formation be included in the Junee Group. The term porphyroid should be restricted to suites of rocks characterised by intense metasomatic metamorphism in the absence of stress. Porphyroid should rank with the terms dynamothermal, thermal, and cataclastic as applied to metamorphism. It is proposed that the usage of " Porphyroid " as a bag name for unidentified and often unaltered rocks (i.e., Twelvetrees's usage), be dropped. In a particular region the term may be given a time significance by prefixing the time of metamorphism as " Devonian Porphyroids " in the case of Western Tasmania.

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LOCALITY INDEX

	Internat. Grid. Reference K/55 Quadrangle	S. Lat.	E. Long.
Adamsfield	Huntly 73	42° 47′	146° 20′
Andrew Divide	Lyell 58	42° 11′	145° 37′
Andrew River	Lyell 58	42° 13′	145° 38′
Anthony Creek	Murchison 51	41° 42′	145° 36′
Baxter River	Lyell 58	42° 12′	145° 42′
Blow	Lyell 58	42° 04′	145° 35′
Bubbs Hill	Lyell 58	42° 07′	145° 46′
Clark River	Macquarie Harb. 64	42° 18′	145° 30′
Comstock Mine	Lyell 58	42° 02′	145° 35′
Comstock Tramway	Lyell 58	42° 03′	145° 34′
Comstock Valley	Lyell 58	42° 03′	145° 38′
Conglomerate Creek	Lyell 58	42° 06′	145° 35′
Crotty	Lyell 58	42° 10′	145° 38′
Crotty Smelters	Lyell 58	42° 10′	145° 37′
Currie River	Lyell 58	42° 10′	145° 31′
Cusick Creek	Lyell 58	42° 03′	145° 31′
Darwin Peak, South	Pillinger 65	42° 18′	145° 36′
Darwin (Town)	Lyell 58	42° 14′	145° 38′
Denison Range	Huntly 73	42° 34′	146° 17′
Dial Range	Devonport 29	41° 11′	146° 01′
Dora Tramway	Murchison 51	41° 58′	145° 38′
Dundas	Zeehan 50	41° 53′	145° 24′
Dunkley's Tramway	Zeehan 50	41° 54′	145° 20′
Eldon Peak	Murchison 51	41° 58′	145° 44′
Eldon Range	Murchison 51	41° 59′	145° 44′
Elliot Range	Pillinger 65	42° 30′	145° 42′
Engineer Range	Pillinger 65	42° 18′	145° 44′
Farrell Junction	Mackintosh 44	41° 43′	145° 34′
Firewood Siding	Zeehan 50	41° 59′	145° 16′
"Gap, The"	Lyell 58	42° 04′	145° 35′
Gordon River	Pillinger 65	42° 45′	145° 45′
Gormanston	Lyell 58	42° 04′	145° 35′
Hawks Creek	Mackintosh 44	41° 42′	145° 40′
Henty Bridge	Zeehan 50	41° 59′	145° 27′
Henty Moraine	Zeehan 50	41° 59′	145° 28′
Henty River	Strahan 57	42° 02′	145° 18′
Hercules Mine	Zeehan 50	41° 50′	145° 30′
Howards Plain	Lyell 58	42° 04′	145° 31′
Howth	Devonport 29	41° 05′	146° 01′
Huntley Cirque	Murchison 51	41° 56′	146° 37′
Kelly Basin	Pillinger 65	42° 21′	145° 34′
King Battery	Lyell 58	42° 07′	145° 32′
King River	Lyell 58	42° 05′	145° 39′
King River Gorge	Lyell 58	42° 11′	145° 30′
King River Packridge	Lyell 58	42° 08′	145° 33′
King River Valley, Upper	Lyell 58	42° 03′	145° 40′
Lake Dora	Murchison 51	41° 58′	145° 39′
Lake Julia	Murchison 51	41° 54′	145° 34′

	Internat. Grid. Reference K/55 Quadrangle	S. Lat.	E. Long.
Lake Margaret	Murchison 51	41° 59′	145° 34′
Lake Rolleston	Murchison 51	41° 55′	145° 37′
Lake Spicer	Murchison 51	41° 59′	145° 40′
Langdon River	Murchison 51	41° 59′	145° 31′
Leven Gorge	Devonport 29	41° 15′	146° 10′
Linda	Lyell 58	42° 04′	145° 37′
Linda Valley	Lyell 58	42° 04′	145° 37′
Little Farrell	Murchison 51	41° 47′	145° 37′
Little Owen	Lyell 58	42° 05′	145° 37′
Lyell Mine, North	Lyell 58	42° 03′	145° 36′
Lyell Mine, West	Lyell 58	42° 04′	145° 35′
Lyell Peak	Lyell 58	42° 03′	145° 37′
Lyell Ridge, North	Lyell 58	42° 03′	145° 36′
Lyell Smelters	Lyell 58	42° 04′	145° 34′
Lynch Creek	Lyell 58	42° 07′	145° 33′
Lynchford	Lyell 58	42° 07′	145° 31′
Lynchford Quarries	Lyell 58	42° 07′	145° 31′
Mackintosh Bridge	Mackintosh 44	41° 44′	145° 36′
Mackintosh River	Mackintosh 44	41° 43′	145° 37′
Mackintosh Valley	Mackintosh 44	41° 43′	145° 37′
Malanna	Strahan 57	42° 01′	145° 13′
Margaret Moraine	Murchison 51	41° 59′	145° 32′
Miners Ridge	Lyell 58	42° 07′	145° 32′
Mt. Balfour	Balfour 34	41° 17′	144° 54′
Mt. Darwin	Lyell 58	42° 16′	145° 36′
Mt. Dundas	Zeehan 50	41° 55′	145° 28′
Mt. Farrell	Mackintosh 44	41° 44′	145° 22′
Mt. Jukes	Lyell 58	42° 11′	145° 36′
Mt. Lyell	Lyell 58	42° 03′	145° 37′
Mt. Misery	Zeehan 58	41° 55′	145° 22′
Mt. Murchison	Murchison 51	41° 50′	145° 36′
Mt. Owen	Lyell 58	42° 06′	145° 37′
Mt. Professor	Zeehan 50	41° 59′	145° 22′
Mt. Read	Murchison 51	41° 53′	145° 33′
Mt. Sedgwick	Lyell 58	42° 00′	145° 35′
Mt. Sorell	Pillinger 65	42° 15′	145° 32′
Mt. Strahan	Strahan 57	42° 13′	145° 28′
Mt. Tyndall	Murchison 51	41° 56′	145° 35′
Mt. Zeehan	Zeehan 50	41° 56′	145° 18′
Murchison Gorge	Murchison 51	41° 51′	145° 42′
Murchison River	Murchison 51	41° 51′	145° 42′
Nelson River	Lyell 58	42° 07′	145° 43′
Newton Creek	Murchison 51	41° 55′	145° 34′
Nora River	Pillinger 65	42° 19′	145° 37′
Pearl Creek	Strahan 57	42° 03′	145° 29′
Pieman River	Corinna 43	41° 50′	145° 20′
Princess River	Lyell 58	42° 04′	145° 41′
Queen River	Lyell 58	42° 07′	145° 33′
Queen River, West	Lyell 58	42° 02′	145° 33′
Queenstown	Lyell 58	42° 05′	145° 33′
Queenstown Quarry	Lyell 58	42° 05′	145° 33′
Queenstown Quarry, South	Lyell 58	42° 06′	145° 33′
Red Hills	Murchison 51	41° 52′	145° 35′
Reservoir Creek	Lyell 58	42° 06′	145° 34′
Roaring Meg Creek	Lyell 58	42° 07′	145° 34′
Rosebery	Murchison 51	41° 48′	145° 32′
Sisters Hills	Strahan 57	42° 01′	145° 28′
Snake Spur	Lyell 58	42° 13′	145° 35′
Sophia River	Mackintosh 44	41° 45′	145° 38′
Sticht Range	Murchison 51	41° 52′	145° 38′
Strahan	Strahan 57	42° 10′	145° 20′

	Internat. Grid. Reference K/55 Quadrangle	S. Lat.	E. Long.
Temma	Bluff Pt. 26	41° 14′	144° 42′
Tim Shea	Huntly 73	42° 43′	146° 29′
Toft Valley	Lyell 58	42° 09′	145° 37′
Tullah	Mackintosh 44	41° 44′	145° 36′
Tyndall Range	Murchison 51	41° 57′	145° 36′
Walfords Peak	Murchison 51	41° 56′	145° 38′
West Coast Range	Murchison 51 / Lyell 58 / Pillinger 65	41° 44′ / 42° 18′	145° 33′ / 145° 38′
Yolande Moraine	Lyell 58	42° 02′	145° 31′
Yolande River	Strahan 57	42° 04′	145° 29′
Zeehan	Zeehan 50	41° 53′	145° 20′
Zig-Zag	Lyell 58	42° 02′	145° 04′

		Lat.	Long.
Giants Range	Minnesota, U.S.A.	48° 10′ N.	93° 20′ W.
Kiruna	Sweden	67° 55′ N.	20° 20′ E.
Lake District	England	54° 35′ N.	3° 10′ W.
Mesabi Range	Minnesota, U.S.A.	49° 37′ N.	92° 04′ W.
Phillipine Is.	—	14° 40′ N.	121° 30′ E.
Porcupine	Ontario, Canada	48° 30′ N.	81° 08′ W.

Plate I

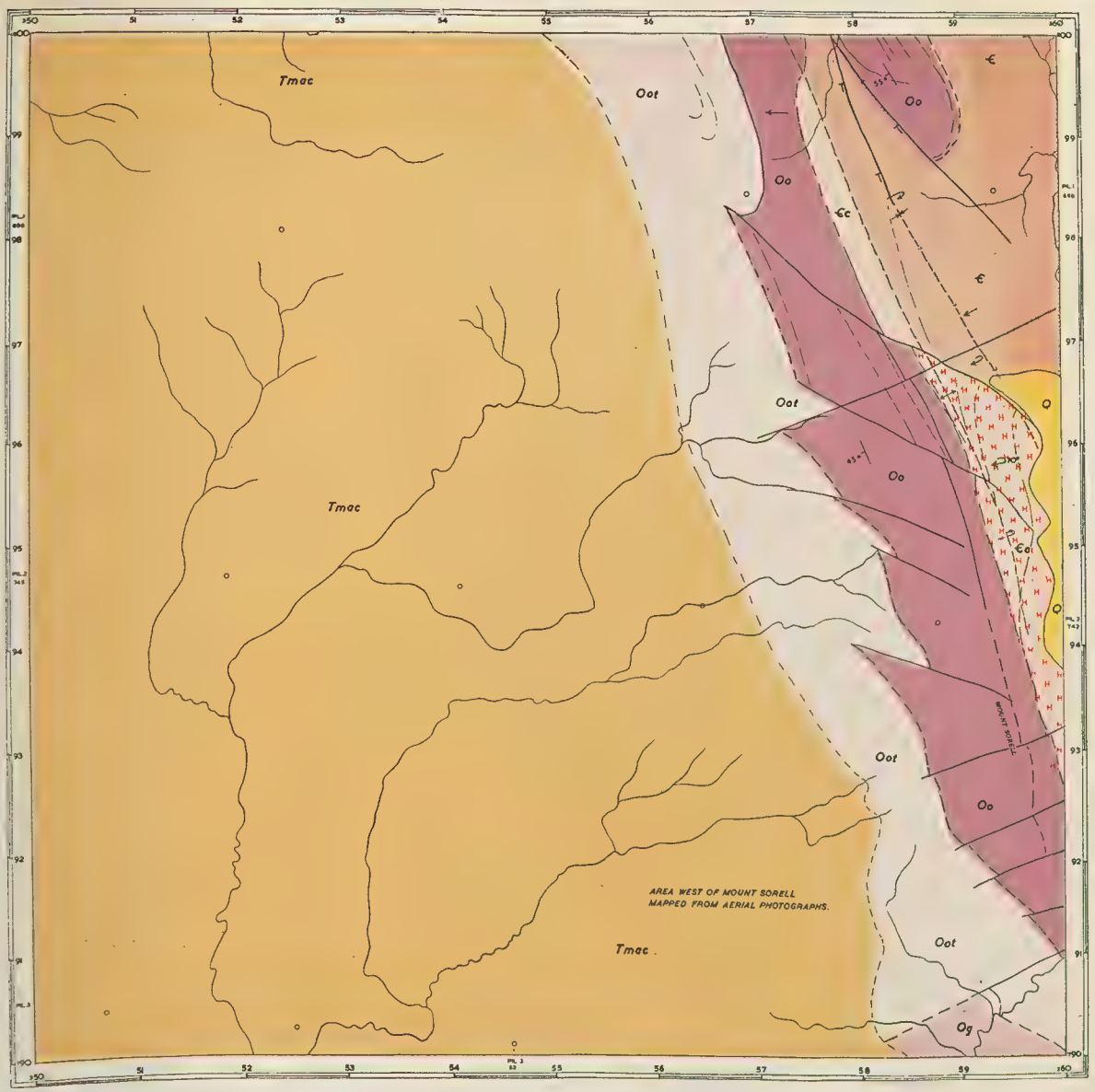
Palimpsest pebbles in granite at grid reference 3636.7946, Mt. Darwin, Tasmania.

GEOLOGY OF TASMANIA

ONE INCH SERIES—UNIVERSITY OF TASMANIA, GEOLOGY DEPARTMENT

MOUNT SORELL

MAP SQUARE 3579



Quaternary System

Q ALLUVIUM AND MORAINES

Tertiary System

Tmac MACQUARIE BEDS

Junee Group

Og GORDON LIMESTONE

Oo OWEN CONGLOMERATE

Oot TUBICOLAR SANDSTONE MEMBER

Dundas Group

Ec CONGLOMERATE AND BRECCIA

€ UNDIFFERENTIATED

METAMORPHIC ROCKS

AREA OF FELSPATHISED ROCK

AREA OF CHLORITISED ROCK

AREA OF HAEMATISED ROCK

KEY MAP SHOWING MAGNETIC VARIATION

LEGEND

FAULT

FAULT — POSITION APPROXIMATE

BOUNDARY

BOUNDARY — POSITION APPROXIMATE

TREND OF OUTCROP

SYNCLINAL AXIS

ANTICLINAL AXIS

STRIKE AND DIP

Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Hydro-Electric Commission. Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

SCALE

0 1 2 MILES

0 1 2 3 4 5,000 10,000 FEET

MAPPED AND COMPILED BY

J BRADLEY JANUARY 1951

SUMMARY OF THE GEOLOGY OF MOUNT SORELL

SHEET 350/790.

PHYSIOGRAPHY.

The topography is of two extreme types In the east is the residual ridge of Mt. Sorell while the centre and west of the area consists of a platform of emergence. This platform is an elevated and declined surface of estuarine deposits. It falls in a west-southwest direction from 400 feet at the base of Mt. Sorell to 80 feet where it is cliffed back on Macquarie Harbour. Dissection is still very youthful with the result that almost half of the initial surface remains. Surface drainage was at first extended but insequent streams have developed a dendritic pattern. The unconsolidated conglomeratic strata allow perfect underground drainage of the higher undissected areas which are consequently stable and may be of considerable age. Dry valleys at the heads of streams show that a more extensive drainage system once existed. These valleys may have been carved under conditions of greater rainfall. Mt. Sorell is a monadnock ridge of quartzite with westerly dip slopes rising to a ridge over 3,500 feet high.. The eastern face of the mountain is a spectacular 1,500 feet precipice. The scarp, due to differential erosion, must have been sharpened by broad cirque-like glaciers on the eastern, lee, side of the mountain.

STRATIGRAPHY.

Tertiary: The Macquarie Beds, on the northern and eastern shores of Macquarie Harbour, consist of some 400 feet of unconsolidated estuarine sediments which in this area dip gently west-southwest. The major portion of the formation is made up of conglomerates and sands. The conglomerates contain pebbles of Owen Conglomerate, occasional porphyroid rocks, and dolerite. They are probably derived from the northeast and could have been deposited by the King. Extensive laminated clays containing detrital wood fragments but no shell fossils occur at several levels. Lignitic peats occurring in lenses up to 30 inches thick and resting on seat earths are common. The age of the formation is only generally deduced as Late Pliocene.

Junee Group: Owen Conglomerate. Tubicolar Sandstone forms the western slopes of Mt Sorell. It is dense pink and white quartzite about 500 feet thick thinning to less than 200 feet in the south. The conglomeratic members of the formation are unusually fine in grade—not more than 2"—3" grade—and sandy beds are common. These rocks are only 300 feet thick and pass out to nothing in the Clark River. The rocks described by Hills as Breccia Conglomerates are not texturally typical of this member. They also are fine, 2"—3" grade, and consist of granite, haematite, magnetite and quartzite pebbles. The Breccias are 450 feet thick and though the contact is not seen they overlie quartz feldspar porphyries at Flannagans Flat. 577/999.

STRUCTURE.

The Macquarie Beds are inclined at about 1°-2°. Round the harbour small folds run parallel to the shore and small faults and shears occur inland for about 100 yards in the clays. These structures are due to slumping of cliffs into the harbour. Looking south from Mt. Strahan an overfold is seen on the north end of Mt. Sorell. This is part of a complete anticline and syncline which die out to the south.

ECONOMIC.

Flannagans Flat was once a rich small goldfield situated on porphyry and limestone pugs.

REFERENCE.

Bradley, J., 1954: The Geology of the Queenstown Area: **Pap. Proc. Roy. Soc. Tas. Vol. 88.**

GEOLOGY OF TASMANIA
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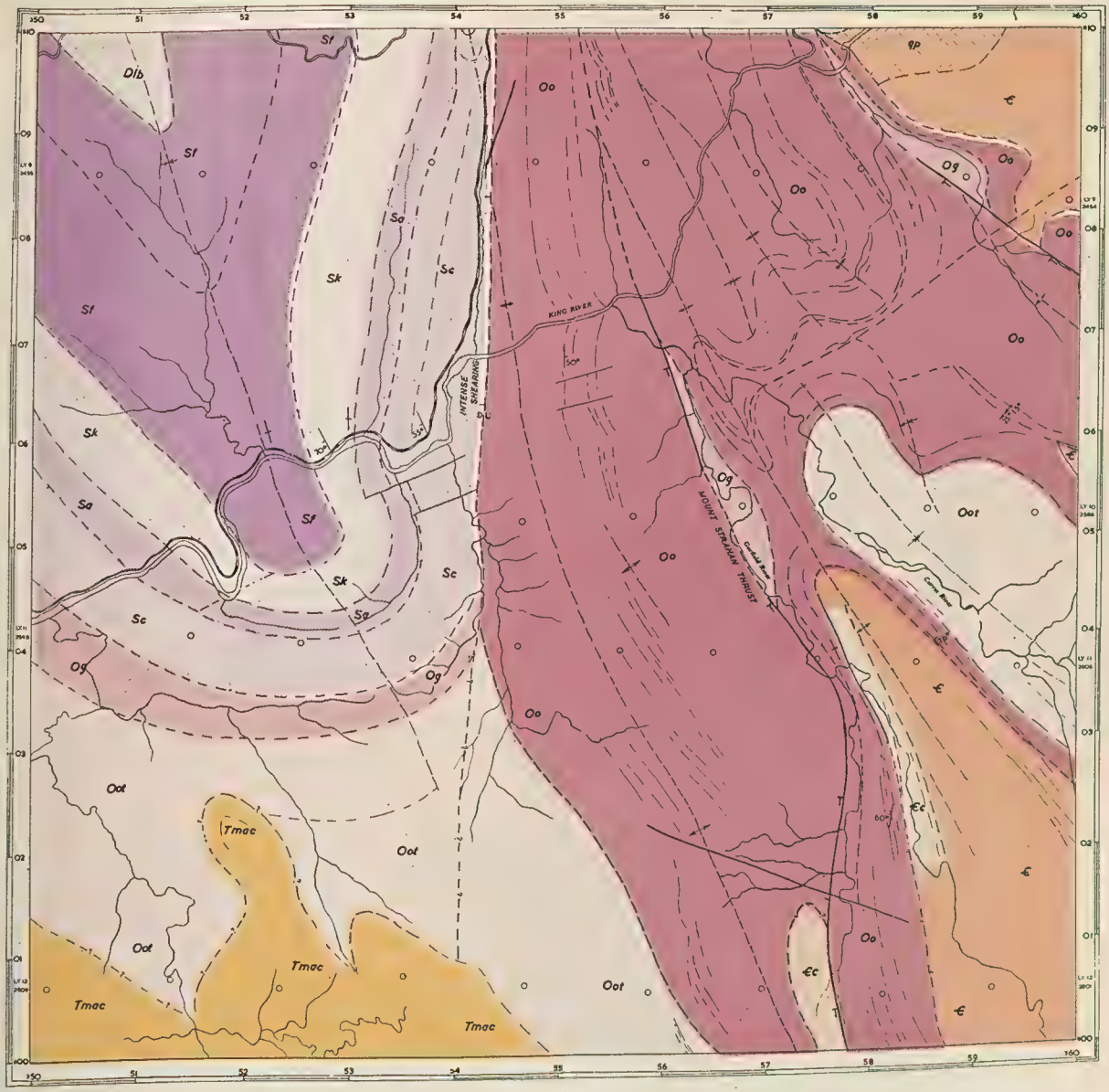
MOUNT STRAHAN

MAP SQUARE 3580



Tertiary System
- Tmac — MACQUARIE BEDS

Eldon Group
- Dlb — BELL SHALE
- Sf — FLORENCE QUARTZITE
- Sk — KEEL QUARTZITE
- Sa — AMBER SLATE
- Sc — CROTTY QUARTZITE
- S — UNDIFFERENTIATED

Junee Group
- Og — GORDON LIMESTONE
- Oo — OWEN CONGLOMERATE
- Oot — TUBICOLAR SANDSTONE MEMBER

Dundas Group
- €c — CONGLOMERATE AND BRECCIA
- € — UNDIFFERENTIATED

METAMORPHIC ROCKS
- AREA OF QUARTZ PORPHYRITISED ROCK
- AREA OF FELSPATHISED ROCK
- AREA OF CHLORITISED ROCK
- gp — QUARTZ PORPHYRY MASSIVE

MAPPED AND COMPILED BY
J BRADLEY JANUARY 1951

LEGEND
- FAULT
- FAULT — POSITION APPROXIMATE
- BOUNDARY
- BOUNDARY — POSITION APPROXIMATE
- BOUNDARY INFERRED
- ANTICLINAL AXIS
- SYNCLINAL AXIS
- TREND OF OUTCROP
- STRIKE AND DIP
- ROAD
- THRUST FAULT, ⊢ ON UPTHROWN SIDE

SCALE
0 1 2 MILES
0 1 2 3 4 5,000 10,000 FEET

Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Hydro-Electric Commission. Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

KEY MAP SHOWING MAGNETIC VARIATION
9° 5°E
10°E
10° 5°E

SUMMARY OF THE GEOLOGY OF MOUNT STRAHAN

SHEET 350/810

PHYSIOGRAPHY.

The area is a highly dissected portion of the uplifted Henty Peneplain. Remnants of this erosional surface occur at 1,000 feet along the northern boundary. Mount Strahan is a monadnock ridge which has persisted from the Henty cycle into the present phase of erosion The King River is superimposed and incised in a gorge some 60 feet deep and its tributaries plunge from narrow gullies. The minor drainage is structurally controlled, sometimes superimposed, and follows softer limestone, shales, and the soft chloritic rocks of the Garfield Anticline. At point 543/069 the character of the King River changes abruptly from graded to actively degrading. This change coincides with the N.-S. (Tertiary?) fault line and the change from softer Eldon rocks to Owen Conglomerate. The conglomerate country has bare scarps and shoulders, in contrast to the forested and prominently ridged Eldon quartzites and shales, and to the flat low areas of limestone. In the southwest a low platform of late Tertiary beds falls west-southwest from 600 feet to near sea level and has a characteristic dendritic drainage.

STRATIGRAPHY.

The Macquarie Beds of the southwest are estuarine conglomerates, sands, clays and lignitic peats. They are about 400 feet thick, are tilted west-southwest and pass below sea level at Macquarie Harbour. They are probably Late Pliocene or Pleistocene in age. Their uplift coincides in part at least, with that of the Henty Peneplain, and involves westerly and southerly tilts in this area.

Eldon Group: Devonian strata (Bell Shale) along with a full normal sequence of Silurian quartzites and shales are exposed along the King River and Strahan Rd. Crotty Sandstone along the railway is not quite typical—it is possible that it is largely faulted out along with the limestone and that some of the strata marked Crotty belong to the Amber formation.

Junee Group: Gordon Limestone is poorly exposed at very few points, e.g., 500/044, 578/092 and 572/045. Owen Conglomerate is mainly represented by quartzites but is very variable, from thin 20 feet grits at 577/099 to 700 feet thick quartzites at 578/038. At the latter locality a thin conglomerate overlies ideally exposed and typical Breccia Conglomerate.

METAMORPHOSED ROCKS.

These are probably Dundas Group strata. They are poorly exposed and have no demonstrable structural continuity. Hornfelses and chlorite sericite schists are the usual rock types.

STRUCTURE.

Folds aligned N.W.-S.E. are strike faulted and thrust. They are intersected by N.E.-S.W. trending complementary folds and faults, e.g., 535/054 to 595/080. A gentle anticline produces the interesting opposed plunging folds, 567/064. The N.-S. fault, 540E, dislocates the Devonian structures and downthrows to the west at least 1,000 feet. It is earlier than the Henty Peneplain which it does not affect, and is probably of Tertiary age.

ECONOMIC.

Flannagans Flat was once a rich small alluvial goldfield. This gold was probably derived from the pyritised contact of porphyry against conglomerate.

POINTS OF INTEREST.

There is scenic interest on the train journey through the King Gorge. The Eldon rocks are conveniently and well exposed on the Strahan Road at many points.

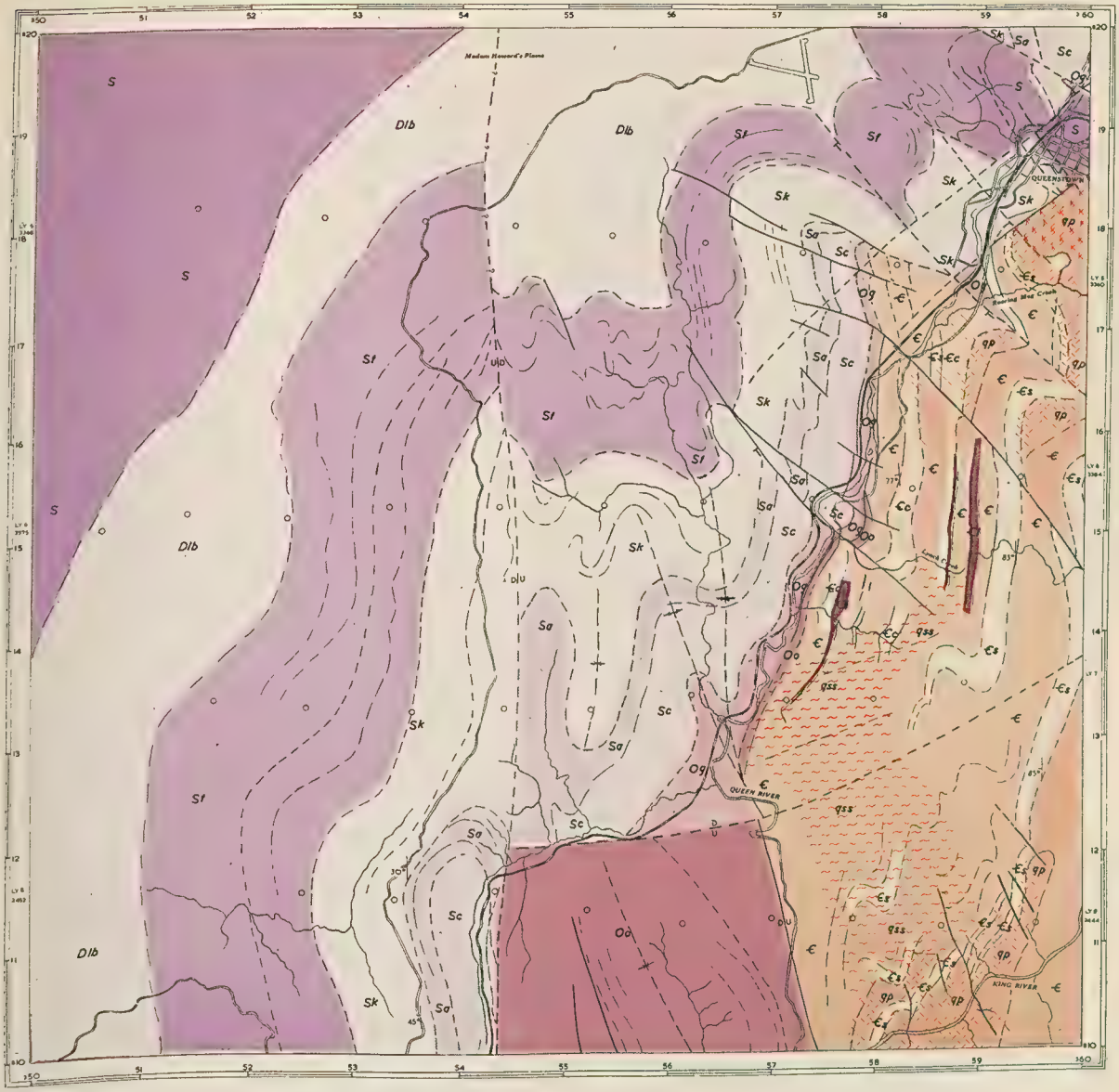
REFERENCE.

Bradley, J., 1954: The Geology of the Queenstown Area: **Pap. Proc. Roy. Soc. Tas. Vol. 88.**

GEOLOGY OF TASMANIA
ONE INCH SERIES-UNIVERSITY OF TASMANIA, GEOLOGY DEPARTMENT

QUEEN RIVER

MAP SQUARE 3581



Eldon Group
- Dlb BELL SHALE
- Sf FLORENCE QUARTZITE
- Sk KEEL QUARTZITE
- Sa AMBER SLATE
- Sc CROTTY QUARTZITE
- S UNDIFFERENTIATED

Junee Group
- Oq GORDON LIMESTONE
- Oo OWEN CONGLOMERATE

Dundas Group
- Ec CONGLOMERATE AND BRECCIA
- Es SLATES
- € UNDIFFERENTIATED

IGNEOUS ROCKS
Dundas Group
- LAVAS

METAMORPHIC ROCKS
- qp QUARTZ PORPHYRY MASSIVE
- AREA OF QUARTZ PORPHYRITISED ROCK
- AREA OF KAOLINISED ROCK
- qss QUARTZ SERICITE SCHIST
- AREA OF FELSPATHISED ROCK

MAPPED AND COMPILED BY
J BRADLEY JANUARY 1951

LEGEND
- FAULT
- FAULT — POSITION APPROXIMATE
- ? FAULT INFERRED
- BOUNDARY
- BOUNDARY — POSITION APPROXIMATE
- TREND OF OUTCROP
- SYNCLINAL AXIS
- ANTICLINAL AXIS
- 30° STRIKE AND DIP
- ROAD
- THRUST FAULT, ⊢ ON UPTHROWN SIDE
- AERODROME

— SCALE —
2 MILES
0 1 2 3 4 5,000 10,000 FEET

Compilation from Aerial Photographs
Trigonometric Station Control by courtesy Hydro-Electric Commission.
Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7

KEY MAP SHOWING MAGNETIC VARIATION
9° 5°E
10°E
10° 5°E

SUMMARY OF THE GEOLOGY OF THE QUEEN RIVER

SHEET 350/810.

PHYSIOGRAPHY.

The area is a gently undulating erosional surface rising from 900 feet to 1,200 feet from west to east. This surface was elevated some 600 feet in late or post-Pliocene time and is still in the initial stages of dissection. Lower courses of streams occupy narrow valleys and the lower Queen and King Rivers flow in gorges 400-600 feet deep. On either side of the Queen River adjustment to structure has produced hogback ridges in the hard Cambrian slates and Silurian quartzites. In the Queen Valley erosion of the Gordon Limestone has produced at 600-700 feet a graded reach of the river with small high terrace remnants.

STRATIGRAPHY.

Estimated thickness of formations are Bell Shale 2,000 feet, Florence Quartzite 1,200 feet, Keel Quartzite 1,500 feet, Crotty Quartzite 1,000 feet, Gordon Limestone 700 feet, Owen Conglomerate missing or represented by 20 feet of quartzite at Lynch Creek Bridge. The Dundas Group is divisible into the Lynch Conglomerate 2,000 feet, the Battery Volcanics 3,000 feet, and the Miners Slate 5,000 feet.

The juncture, between the quartzites and greywacke conglomerates at Lynch Creek Bridge, or elsewhere, between the limestone and the Dundas Group, represents a break in deposition and is possibly erosional. There is no angular discordance between the formations.

IGNEOUS ROCKS.

Vesicular spilites of Cambrian age occur in Lynch Creek 587/147 and Specimen Creek 575/142. Tuffaceous breccias associated with these lavas are thick and extensive.

METAMORPHIC ROCKS: 'Porphyroids.'
Quartz porphyries on Roaring Meg Creek and the King River are normal types. They contain numerous slate inclusions and beds of slate. At Queenstown the porphyry is intensely kaolinised, 595/182. From Lynch Creek to Roaring Meg Creek the coarser greywackes grade into feldspar porphyry, quartz feldspar porphyry and quartz porphyry. Palimpsest bedding and fragments are common in the porphyries. The rocks carry veins and vughs of epidote and pink albite. They are massive and lightly sheared. The "slates" are indurated and sheared, but not cleavable, greywacke siltstones and mudstones. They are hornfelsed towards the quartz porphyries.

PETROLOGY.

The Cambrian lavas are spilitic. Feldspars, albite-oligoclase, are secondary in many cases, and augite alters to chlorite and tremolite. Asbestiform tremolite veins the rock and chlorite and calcite fill vesicles. The greywackes are free of quartz and contain augite. Initial stages of alteration show growth of interstitial quartz and albite porphyroblasts. With the growth of macroscopic feldspars (oligoclase) chloritisation and epidotisation occur. Some development of tremolite after augite is common. Growth of quartz phenocrysts is accompanied by sericitisation of feldspar and removal of FeMg minerals.

STRUCTURAL GEOLOGY.

Strata generally dip west at 70°, minor structures, thrusts and overturned folds are aligned N.W.-S.E. Folding is most pronounced in the Eldon quartzites but dies out in the Bell Shale and passes downwards into thrusts and minor shears. A complementary set of folds and faults trending N.E.-S.W are not so prominent.

ECONOMIC GEOLOGY.

Gold occurs in creeks draining the porphyries but is unimportant. Galena in limestone occurs at Queenstown 597/183. Limestone at Lynchford is the only worked deposit.

POINTS OF SPECIAL INTEREST.

Queenstown Limestone Quarry 598/194. This, and outcrops due east across the Queen, are fossiliferous Gordon Limestone. Fossils extracted include **Alveolites** sp., **Protarea** cf. **richmondensis Acidolites, Tetradium tasmaniense, Acantholites, Favistella, Favosites,** Aulorporid corals, bryozoa and gastropods.

South Queenstown 583/158. Porphyritised breccias occur alongside timber tracks leading east from the road. These tracks also expose sections of the uppermost Dundas rocks.

Lynch Creek. The section is structurally unbroken for 2 miles. Lavas occur in the track on the northern side of the stream for half mile after passing the King Battery.

Roaring Meg Creek. 595/174. Quartz Porphyry contact with slates.

REFERENCE.

Bradley, J., 1954: The Geology of the Queenstown Area: **Pap. Proc. Roy. Soc. Tas. Vol. 88.**

YOLANDE RIVER

GEOLOGY OF TASMANIA

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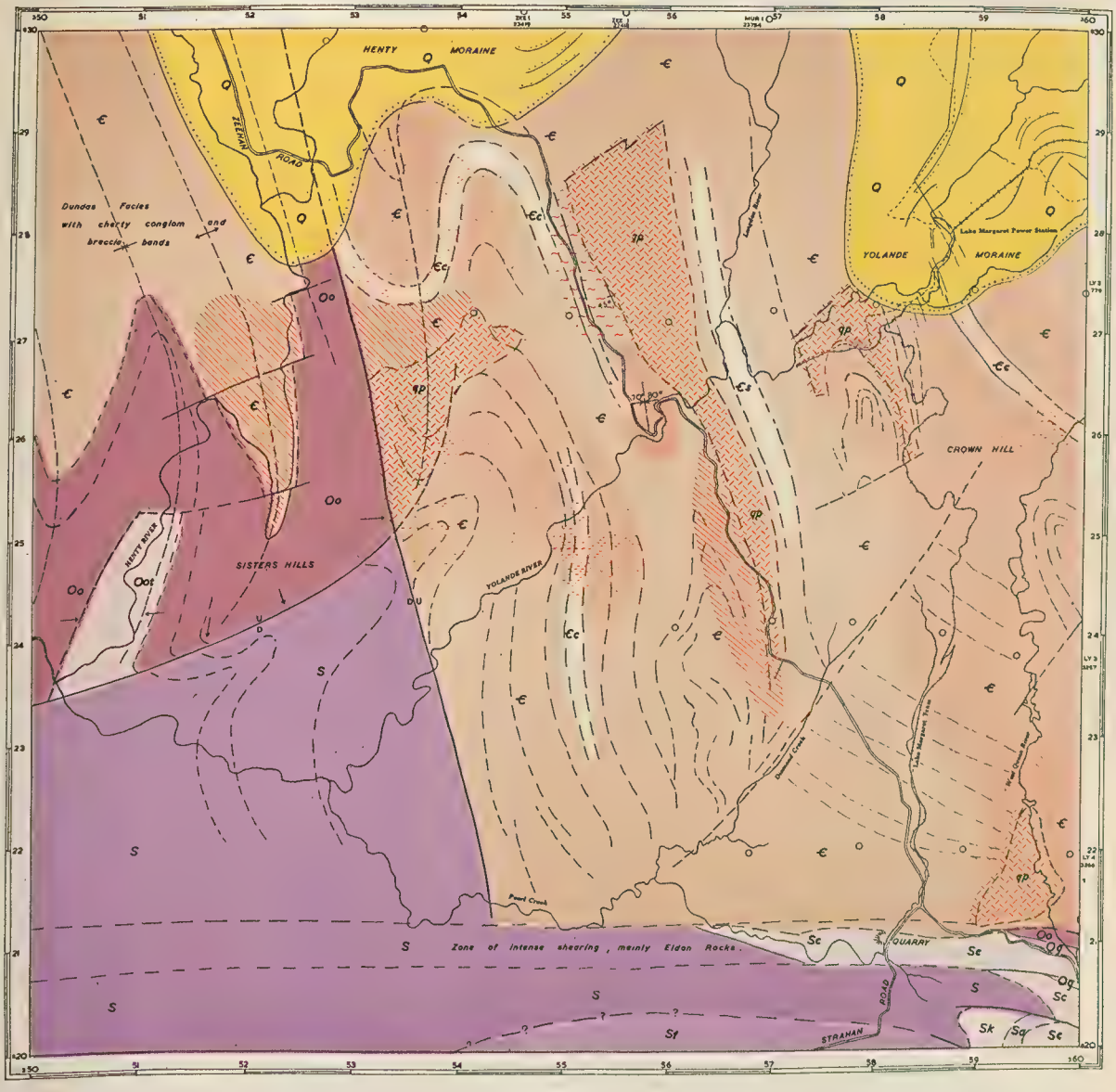
MAP SQUARE 358



LEGEND

Quaternary System
- O — ALLUVIUM AND MORAINES

Eldon Group
- St — FLORENCE QUARTZITE
- Sk — KEEL QUARTZITE
- Sa — AMBER SLATE
- Sc — CROTTY QUARTZITE
- S — UNDIFFERENTIATED

Junee Group
- Og — GORDON LIMESTONE
- Oo — OWEN CONGLOMERATE
- Oot — TUBICOLAR SANDSTONE MEMBE

Dundas Group
- €c — CONGLOMERATE AND BRECCIA
- €s — SLATES
- € — UNDIFFERENTIATED

METAMORPHIC ROCKS
- qp — QUARTZ PORPHYRY MASSIVE
- AREA OF QUARTZ PORPHYRITISED ROCK
- AREA OF FELSPATHISED ROCK
- AREA OF CHLORITISED ROCK
- qss — QUARTZ SERICITE SCHIST

MAPPED AND COMPILED BY
J BRADLEY JANUARY 1951

- FAULT
- FAULT – POSITION APPROXIMATE
- BOUNDARY
- BOUNDARY – POSITION APPROXIMATE
- BOUNDARY INFERRED
- TREND OF OUTCROP
- SYNCLINAL AXIS
- ANTICLINAL AXIS
- 5° STRIKE AND DIP
- MORAINE
- TRAM
- ROAD
- TRACK
- ADIT

Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Hydro-Electric Commission. Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

KEY MAP SHOWING MAGNETIC VARIATION

9° 5° E
10° E
10° 5° E

— SCALE —

0 1 2 MILES
0 1 2 3 4 5000 10,000 FEET

SUMMARY OF THE GEOLOGY OF THE YOLANDE RIVER SHEET 350/820.

PHYSIOGRAPHY.

The area has an undulating and mature erosional surface, the Henty Peneplain, rising from 900 feet in the west, to 1,200 feet in the east. The Sisters Hills are conical monadnocks rising 400 feet above the plain while the gorges of the rejuvenated Henty and Yolande Rivers are incised 400 feet. The southern margin of the area is defined by a low, 200 feet range of hills formed of the friable but chemically resistent Crotty Sandstone. The minor drainage, including the heads of Pearl Creek and East Queen River, is mature and of an older cycle. The tributary junctions of the Henty and Yolande are discordant. The Henty, above Sisters Hills, is graded while the Yolande is actively degrading. The topography suggests the relatively recent uplift of this country, perhaps in late Pliocene or early Pleistocene times.

GLACIATION.

The Margaret Moraine, formed by the Lake Margaret glacier, is of unusual character. The steep declivity of Mt. Sedgwick on its western side caused the superposition of almost all retreat stages along this line so that one vast moraine 900 feet high up the west side is built up to the edge of the plateau. Very minor retreat phenomena are visible above this moraine. The scanty Yolande Moraine represents an earlier advance of the ice but is very difficult to date. The Henty Moraine marks a relatively brief advance of the Henty glacier and is shown, 544/290, by perched erratics and thick tills, 520/290. The Henty Valley is V rather than U shaped and shows few signs of ice wear. Grading of the river has been hastened by slight glacial erosion and deposition. Over the rest of this area the absence of glacial till, erratics, and glacial erosion phenomena, along with the presence of deep old soils, indicates that there was no glaciation beyond the moraines.

STRATIGRAPHY.

Eldon Group: Crotty Quartzites occur at the quarry 581/211.

Junee Group: Gordon Limestone occurs only as residual pug. Owen Conglomerate: Tubicolar Sandstone forms most of the Sisters Hills and is about 200 feet thick. The underlying conglomerate beds are quartzose, up to 2" grade and contain pebbles of quartz porphyry.

Dundas Group: Breccias, conglomerates, and chert pebble bands occur in the area (510/290) and pass conformally upwards into Owen Conglomerate. Isoclinally folded strata occur over the rest of the area in indecipherable sequences of slaty beds, tuffaceous breccias, and conglomerates. Folds are traceable, however, and a maximum thickness of about 10,000 feet of strata is deduced.

METAMORPHISM.

Quartz porphyries are concordant and stratiform, and vary laterally into feldspar porphyries and albitised tuffs. At the roadstone quarry, 568/241, occur such tuffs with vughs containing albite, epidote, and galena. In the area 590/250 to 598/262 feldspar porphyries, uniform on broken surfaces and in section, show perfect palimpsests of fragments on weathering. Despite contortion and shearing among these rocks there is little trace of schistosity and slaty cleavage is rare. Adjacent beds react very differently to metamorphism and make it difficult to sort out zones. Chloritised, albitised and silicified strata all appear within distances of ¼ mile and interdigitate in a manner dependent on the initial composition and texture of the rock.

STRUCTURE.

A very broad (½ mile) zone of intense crushing and faulting downthrows Eldon rocks along the southern margin of the area. This fault zone is situated on a tear fault with an easterly displacement on the southern side. The rest of the area is folded on W.N.W. axes with folds tightening to the east. Complementary structures, mainly faults, run in arcs broadly N.E.-S.W. Of these, the fault 500/234-534/250 is a faulted overfold overriding to the S.E. and dying out to the north. All of these are Devonian structures. The fault 523/300-545/210 runs for many miles north and south and dislocates most other structures. It is of a different age, probably Tertiary.

ECONOMIC.

Only road metal is taken in the area but galena showings occur at several points along the crush zone 581/211, at the base of the conglomerates 523/255, and scattered with pyrites in the porphyries. Barytes veins trending W.S.W. occur at 580/220.

POINTS OF INTEREST.

Yolande Hill. 569/246: View of West Coast Range structures, Margaret Moraine, and Henty Peneplain.
Henty Hill. 544/290: Perched erratics and till of Henty Moraine.
Lake Margaret Track and Haulage: View of Henty Peneplain and of glacial features.
Strahan Road. 597/208: Talus breccias are the result of slumping of Crotty Sandstone.
Zeehan Road. 580/220: Barytes veins.

REFERENCE.

Bradley, J., 1954: The Geology of the Queenstown Area: **Pap. Proc. Roy. Soc. Tas. Vol. 88.**

GEOLOGY OF TASMANIA

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MOUNT DARWIN

MAP SQUARE 3679

Quaternary System

- Q — ALLUVIUM AND MORAINES

Eldon Group

- Sk — KEEL QUARTZITE
- Sf — FLORENCE QUARTZITE
- Sa — AMBER SLATE
- Sc — CROTTY QUARTZITE

Junee Group

- Og — GORDON LIMESTONE
- Oo — OWEN CONGLOMERATE
- Oe — ENGINEER QUARTZITE
- Oot — TUBICOLAR SANDSTONE MEMBER

Dundas Group

- Ec — CONGLOMERATE AND BRECCIA
- Es — SLATES
- € — UNDIFFERENTIATED

Metamorphic Rocks

- qp — GRANITE, MASSIVE (QUARTZ PORPHRY)
- AREA OF QUARTZ PORPHYRITISED ROCK
- AREA OF FELSPATHISED ROCK
- AREA OF CHLORITISED ROCK
- AREA OF HAEMATISED ROCK
- qss — QUARTZ SERICITE SCHIST
- ORE OF 5% COPPER

MAPPED AND COMPILED BY
J BRADLEY JANUARY 1951

LEGEND

- FAULT
- FAULT – POSITION APPROXIMATE
- BOUNDARY
- BOUNDARY – POSITION APPROXIMATE
- TREND OF OUTCROP
- ANTICLINAL AXIS
- SYNCLINAL AXIS
- 5° STRIKE AND DIP
- ROAD
- TRACK
- △ HORIZONTAL CONTROL STATION
- THRUST FAULT, ⊢ ON UPTHROWN SIDE

– SCALE –

0 1 2 3 4 5000 2 MILES 10,000 FEET

Compilation from Aerial Photographs. Trigonometric Station control by courtesy Hydro – Electric Commission. Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

KEY MAP SHOWING MAGNETIC VARIATION

SUMMARY OF THE GEOLOGY OF MOUNT JUKES

SHEET 360/800.

PHYSIOGRAPHY.

Mt. Jukes is a rugged scarped mass of hard old rocks and has several summits concordant, at about 3,200 feet, with other peaks of the West Coast Range and the resurrected, but here deeply dissected, Permian peneplain. In the King Basin, erosion surfaces at 1,100 and 700 feet occur. The first of these, quite even and falling away to the south, is maturely dissected, and shows as strike ridges in Silurian quartzites. The second, substantially the old King Valley flood plain level, is now undergoing a further stage of dissection along the main streams. The detail and mass of the topography is, however, adapted to structure: Mt. Jukes is an asymmetric anticline with gentle westerly dip slopes. The eastern limb is carved by a series of cirques and their effluent streams into sharp spurs and valleys directed southeast. These valleys are carved in the cores of the subsidiary northwesterly anticlines while the ridges are essentially synclinal remnants of hard covering conglomerates. The eastern margin of the block is a steep wall of vertical conglomerates. The Andrew River, cutting back in limestone, has captured the head of the Baxter River, which, now a minor stream, flows by vast and recent terraces. The King River is superimposed, but originally made its way across the range by the low syncline and faults north of Mt. Jukes. Almost continuous glacial cirques under the lee of Jukes were the site of very local glaciers which, though failing to reach below 1,500 feet, cut a magnificent escarpment.

STRATIGRAPHY.

Eldon Group: Crotty Sandstone, very like that at Zeehan, occurs throughout the area. Other Silurian formations are more uniform in this area than at Zeehan and being thrust and folded are difficult to distinguish and represent.

Junee Group: Gordon Limestone exposures occur in small patches in the rejuvenated King and Andrew Rivers. Owen Conglomerate: the type section of Loftus Hills is at 625/074, the total thickness being 2,000 feet. The section on the Andrew is about 600 feet thick, and mainly of sandstones, while at Camp Creek the thickness is less than 250 feet, and at Darwin Spur only 150 feet. Breccia Conglomerates are seen in the Main Jukes cliff 624/074.

METAMORPHOSED ROCKS.

Rocks everywhere below the conglomerates are of metamorphosed greywacke types (porphyroids) and are probably of the Dundas Group. The quartz feldspar porphyries below Upper Lake Jukes 625/060, are clearly bedded and contain bands of small quartz pebbles. The occurrence of quartz pebbles in the porphyroid rocks is unique for this district.

STRUCTURE.

An anticlinal structure and fault scarp, 620E, facing east was in existence before the Breccia Conglomerates were formed. Fault scarp talus and succeeding Owen Conglomerate, coming from the east, filled the fault angle depression and finally overlapped it. Renewed compression in Devonian times from the west and south west caused further folding some of which (the 620E shear and monocline) followed the earlier lines.

ECONOMIC.

The latest fault lines are those on which alteration and mineralisation are most pronounced. They are the N.E.-S.W. and the 620E faults. Numerous haematite bodies occur on the 620E line and veins of copper sulphides occur at Lake Jukes. A low grade deposit occurring under Snake Spur in a sericite schist is clearly replacing a bed of shale.

POINTS OF INTEREST.

Lake Jukes Track: Glaciation and metamorphism.

Mt. Jukes: 625/074: Type section for Owen Conglomerate.

Crotty Station: 675/063: Section of Crotty Sandstone.

East Jukes Peak: View of Huxley Syncline and King River Gorge.

REFERENCE.

Bradley, J., 1954: The Geology of the Queenstown Area: **Pap. Proc. Roy. Soc. Tas. Vol. 88.**

GEOLOGY OF TASMANIA

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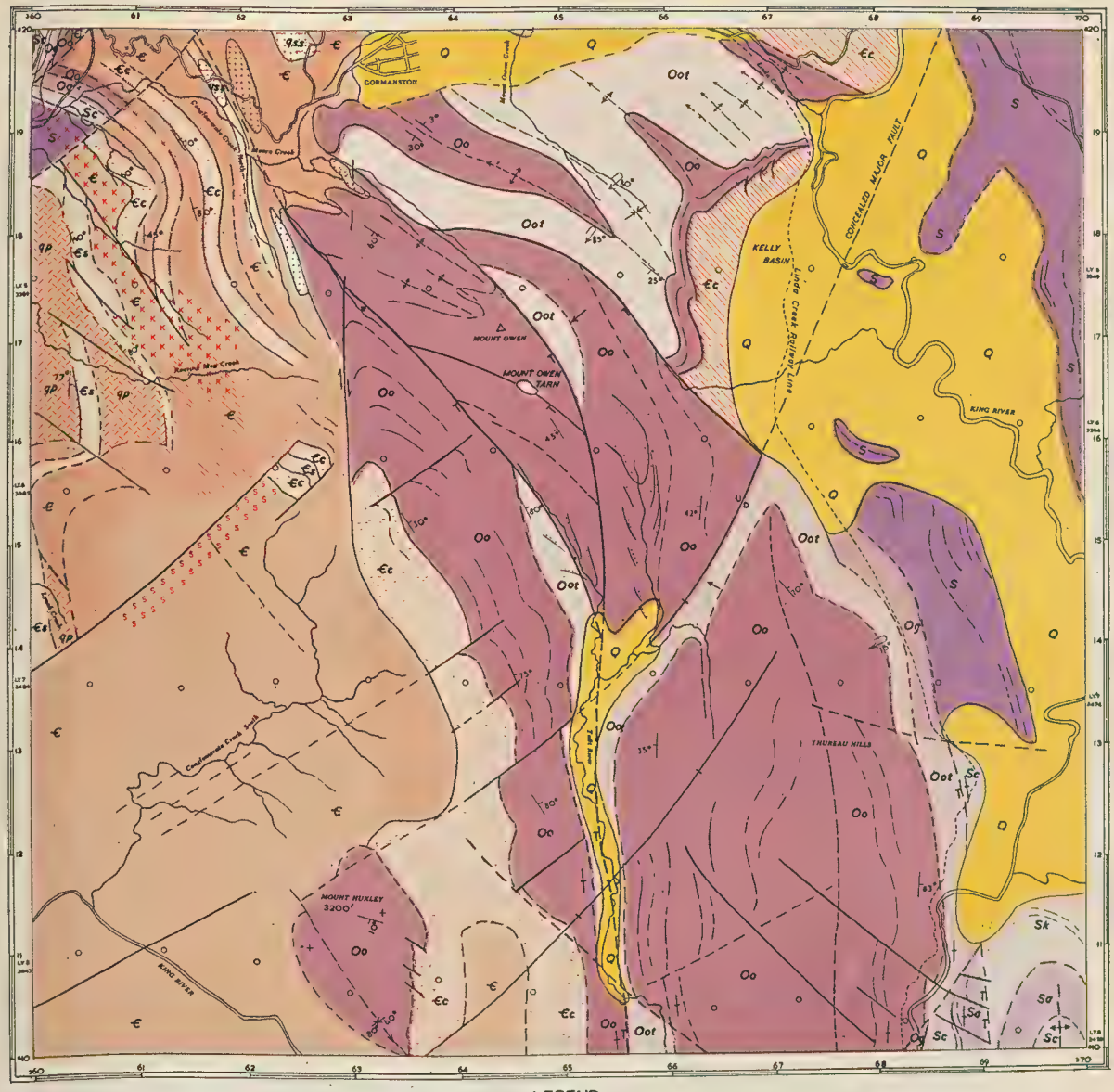
MOUNT OWEN

MAP SQUARE 3681



LEGEND

Quaternary System

- Q — ALLUVIUM AND MORAINES

Eldon Group

- Sk — KEEL QUARTZITE
- Sa — AMBER SLATE
- Sc — CROTTY QUARTZITE
- S — UNDIFFERENTIATED

Junee Group

- Oq — GORDON LIMESTONE
- Oo — OWEN CONGLOMERATE
- Oot — TUBICOLAR SANDSTONE MEMBER

Dundas Group

- Ec — CONGLOMERATE AND BRECCIA
- Es — SLATES
- € — UNDIFFERENTIATED

METAMORPHIC ROCKS

- 9R — QUARTZ PORPHYRY MASSIVE
- AREA OF QUARTZ PORPHYRITISED ROCK
- AREA OF FELSPATHISED ROCK
- AREA OF CHLORITISED ROCK
- AREA OF PYRITISED ROCK
- AREA OF KAOLINISED ROCK
- 9Rs — QUARTZ SERICITE SCHIST
- AREA OF SERICITISED ROCK

MAPPED AND COMPILED BY
J BRADLEY JANUARY 1951

- FAULT
- FAULT — POSITION APPROXIMATE
- BOUNDARY
- BOUNDARY — POSITION APPROXIMATE
- TREND OF OUTCROP
- SYNCLINAL AXIS
- ANTICLINAL AXIS
- STRIKE AND DIP
- MORAINE
- ROAD
- TRACK
- RAILWAY
- HORIZONTAL CONTROL STATION
- THRUST FAULT — ON UPTHROWN SIDE

— SCALE —

0 1 2 3 4 MILES

0 5,000 10,000 FEET

Compilation from Aerial Photographs
Trigonometric Station Control by courtesy Hydro-Electric Commission
Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

KEY MAP SHOWING MAGNETIC VARIATION

9° 5° E

10° E

10° 5° E

SUMMARY OF THE GEOLOGY OF MOUNT OWEN

SHEET 360/810.

PHYSIOGRAPHY.

Mounts Owen and Huxley form a physiographic unit bounded by the Linda Creek and King and Queen River valleys. These valleys lie at 500 to 700 feet and the summits of the range at 3,200 feet+. The mountains are monadnocks. The topography is structurally controlled, the range being an asymmetric anticline and the King Valley a syncline. The Linda Valley and the King Gorge are transverse synclines and the King River, though now incised in quartzite, was originally established in limestones 600 feet above the present river. The core of the range is of hard quartzites and the synclines are of limestone and sandstone. The thrusts of Mt. Owen and the deep syncline of the Tofft River allow the erosion of the country into blocks and pinnacles while N.W. and N.E. shearing determines the minor drainage. South of N160 the King Valley is beautifully terraced and the river, rejuvenated to a point 694/154, cuts through the valley fill of the terraces into bedrock.

GLACIATION.

North of the line N160 the King Valley was glaciated by a broad ice sheet which probably contributed material to the terraces. Dry glacial overflow channels at 683/130 are related to the highest terrace. On Mt. Owen a tarn occupies a small cirque whose glacier must have dammed the then Tofft River. The natural outlet for this stream is the wide low valley to the north-east but drainage is still south through the gorge cut by the Tofft lake overflow.

STRATIGRAPHY.

Eldon Group: The King Slate, 695/194, containing distorted casts of crinoids and brachiopods, is of great thickness 3,000 feet+. With scattered outcrop and complex and unknown structure it may represent much more than the Bell Shale of Devonian age. Crotty Sandstone is identifiable at 688/100.

Junee Group: Gordon Limestone is mapped by residual pugs but rarely seen. The most interesting exposure is faulted in schists at 605/193. Owen Conglomerate is variable. At 605/194 ten feet of quartzite underlies limestone. At 644/160 the conglomeratic phase is 1,500 feet thick. At 665/180 the Tubicolar Sandstone overlies 250 feet of chocolate shales and is 200 feet thick. The basal breccias are well developed east of Huxley.

Dundas Group: In this area no sequences are determinable. Slump structures rhythmically repeated, are preserved in silicified fine grained greywacke at the knoll 620/155. Altered columnar lavas (so-called keratophyres) occur in Conglomerate Creek 616/128. Pebble beds at 665/180 are almost wholly of quartz porphyry and are conformable below Owen Conglomerate. Elsewhere Dundas strata are highly metamorphosed and unrecognisable.

METAMORPHISM.

This is similar to that of Lyell and Queen River areas but schistosity is more pronounced and exposures are poorer. The rocks at 607/194 are chloritised, kaolinised, sericitised and silicified, and are very like the Killas and associated rocks of Cornwall.

STRUCTURE.

The main structure is the asymmetric fold of the range but this is complicated by several smaller oblique folds and thrust masses in complementary sets. The more prominent set of thrusts trends in north-westerly striking arcs which join together to form the vertical limb of the main fold along the Tofft River. The remarkable line of upturning at Lyell persists southwards into this area. This structure is a faulted monocline with northerly movement and upthrow on the west side. It was formed during an Upper Cambrian orogeny as an east facing scarp and was a line of intrusion and movement then and in Devonian times. The Breccia Conglomerates occur east of this line probably originating as a fault scarp breccia.

ECONOMIC.

Outlying ore bodies of the Lyell mines clearly replace bedded rocks. More diffuse pyritic bodies occur along most of the conglomerate-schist contact and richer showings occur below Mt. Huxley 630/097.

POINTS OF INTEREST.

Lyell Highway, 696/194: fossiliferous Eldon slates.
Linda Valley, 661/196: Chocolate shales.
Gormanston, 632/196: Varves.
Lyell Highway, 620/193: Pyritic bodies, view of Owen thrusts.
Conglomerate Creek: Stream section of chloritised rocks.
Mt. Owen, 644/170: by track from Gap—view of Owen tarn and country.

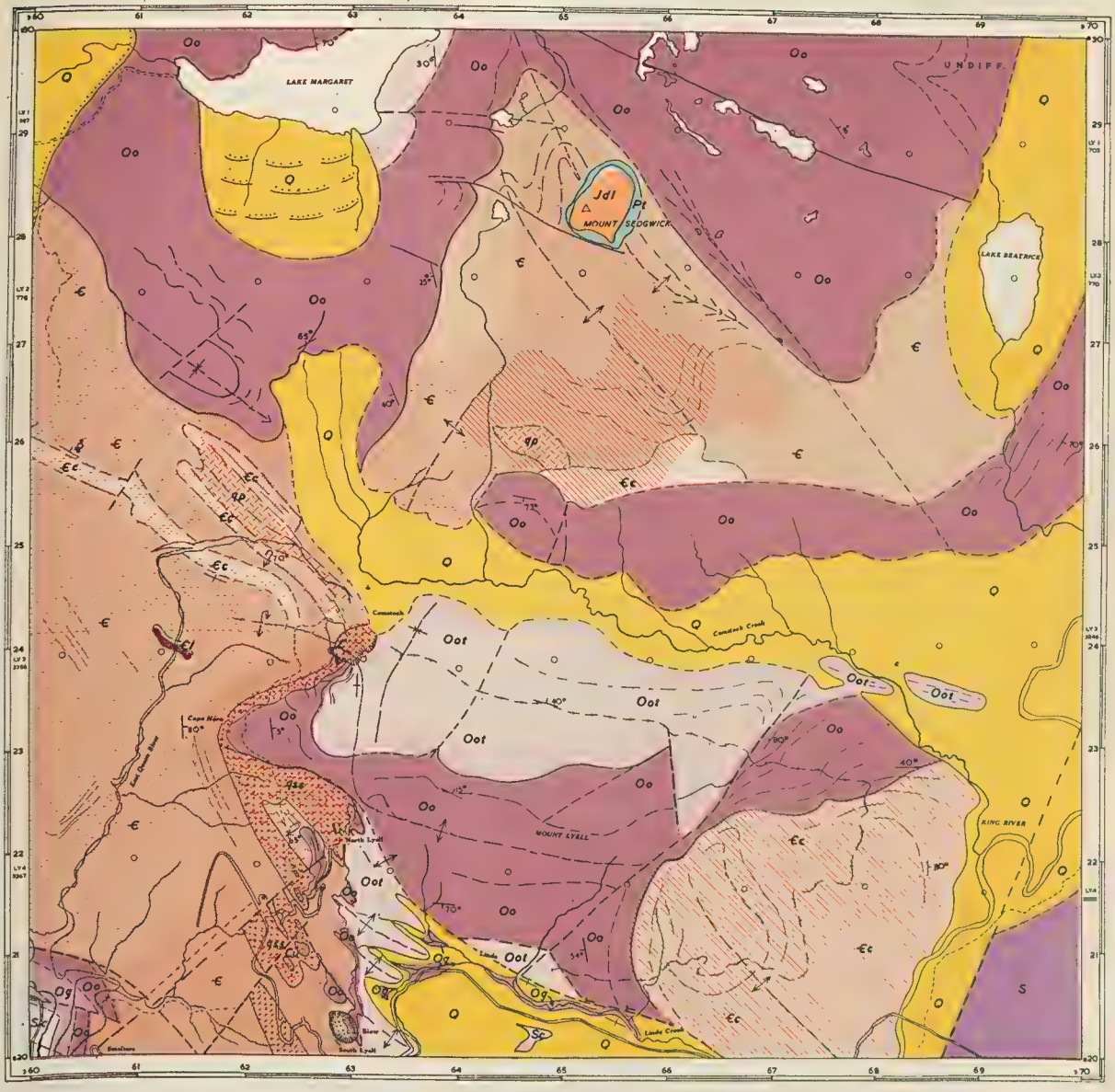
REFERENCE.

Bradley, J., 1954: The Geology of the Queenstown Area: **Pap. Proc. Roy. Soc. Tas. Vol. 88.**

GEOLOGY OF TASMANIA
ONE INCH SERIES — UNIVERSITY OF TASMANIA, GEOLOGY DEPARTMENT.

MOUNT SEDGWICK

MAP SQUARE 3682



Quaternary System
- Q — ALLUVIUM AND MORAINES

Permian System
- Pt — TILLITE

Eldon Group
- Sc — CROTTY QUARTZITE
- S — UNDIFFERENTIATED

Junee Group
- Og — GORDON LIMESTONE
- Oo — OWEN CONGLOMERATE
- Oot — TUBICOLAR SANDSTONE MEMBER

Dundas Group
- Ec — CONGLOMERATE AND BRECCIA
- € — UNDIFFERENTIATED

IGNEOUS ROCKS
Jurassic System
- Jdl — DOLERITE

Dundas Group
- LAVAS

METAMORPHIC ROCKS
- qp — QUARTZ PORPHYRY MASSIVE
- AREA OF QUARTZ PORPHYRITISED ROCK
- AREA OF FELSPATHISED ROCK
- AREA OF CHLORITISED ROCK
- AREA OF PYRITISED ROCK
- qss — QUARTZ SERICITE SCHIST
- ORE OF 1·5% Cu

LEGEND
- FAULT
- FAULT — POSITION APPROXIMATE
- BOUNDARY
- BOUNDARY — POSITION APPROXIMATE
- TREND OF OUTCROP
- 5° STRIKE AND DIP
- ANTICLINAL AXIS
- SYNCLINAL AXIS
- ROAD
- TRACK
- RAILWAY
- MORAINE
- OPEN CUT
- VERTICAL DIP

— SCALE —
0 1 2 3 4 5,000 10,000 2 MILES

Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Hydro-Electric Commission. Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

KEY MAP SHOWING MAGNETIC VARIATION
9·5°E
10°E
10·5°E

MAPPED AND COMPILED BY
J BRADLEY JANUARY 1951

SUMMARY OF THE GEOLOGY OF THE MOUNT SEDGWICK SHEET 360/820.

PHYSIOGRAPHY.

Mt. Sedgwick is a erosional plateau, altitude 3,000 feet, and is bounded by Lake Beatrice 900 feet, Comstock Creek 800 feet, and the Henty Peneplain 1,000-1,200 feet. The plateau, scored by torrents and ice action, is a resurrected (Carboniferous) peneplain. Forming the Peak is a sugar-loaf residual of dolerite overlying thin Permian tillite which in turn rests on the peneplain.

Comstock Valley, Mt. Lyell 2,700 feet, and Linda Valley 800 feet are structural surfaces being more or less the top of the Owen Conglomerate stripped of softer limestone. The fall on the west from the monadnock-like West Coast Range to the softer rocks of the Henty Peneplain is precipitous and is often controlled by erosion on Devonian fault lines

GLACIATION.

Lakes Margaret and Beatrice are over deepened and their exits are margined by moraines. At its maximum some of the Lake Margaret ice spilled over into the head of Comstock Creek forming a low-level cirque. A minor cirque forms the recess south-east of Lyell Peak. Comstock and Linda Valleys were the sites of proglacial lakes dammed by an ice sheet from the east. This ice occupied the northern end of the King Valley rounding off slate knolls and leaving tills. The Comstock Lake outflow cut a channel, the upper course of the East Queen River 620/250, and the Linda Lake outflow a channel at the Gap 633/198. Varved clays at Gormanston reach as high as the latter (now debris-filled) channel. Ice did not at any stage pass west of Lyell.

STRATIGRAPHY.

Eldon Group: King Slate Bell Shale 689/201 sparsely fossiliferous grey slates. Crotty Sandstone, 647/202, is a typical friable white quartz sandstone.

Junee Group: Gordon Limestone occurs in Linda Creek, 653/205, and as black pug, 641/208. Owen Conglomerate: Tubicolar Sandstone forming the erosional surface of plunging folds 635/212 is 200 feet thick. Unconformity: An angular break is seen at foot of Haulage, 633/204. Conglomerates 2,000 feet: Conglomerates, quartzites and Shales.

----------Unconformity and/or metamorphic contact----------

Dundas Group: Porphyroid conglomerates, slates, tuffs and lavas including fluxion banded trachyte (614/238) occur in various degrees of metamorphism.

METAMORPHISM.

Altered rocks include the Mt. Lyell schists and porphyries, i.e., chlorite, sericite, and quartz sericite, schists and feldspar and quartz porphyries. The porphyries are bedded conglomerates and breccias in which pebbles and matrix have had feldspar and quartz porphyroblasts introduced. The schists are localised in areas of strong shearing and are either schisted porphyry or schisted shaly bands of Owen Conglomerate. Metasomatic replacement is zoned in a descending order of haematitisation, pyritisation, sericitisation and choritisation, and albitisation, but recession of fronts has imposed outer zones on inner. Hence it is common to find sericitised and schisted feldspar porphyry which was originally a conglomerate.

STRUCTURE.

The above processes are controlled by lines of fracture and structures of Devonian age. Mt. Lyell and Linda Valley are anticline and syncline respectively, the Linda Syncline having minor folds. The line Old Blow-North Lyell-Comstock is a vertical and faulted monocline uplifted to the west. The broken intersections of folds are favourable for passage of solutions and ore deposition.

ECONOMIC.

Disseminations of pyrite and chalcopyrite occur adjacent to the metamorphic contact and tend to be restricted to favourable beds in the schists. The present West Lyell mine open-cuts 2×10^6 tons of 0.5% Cu ore which is a chlorite sericite pyrite schist with variable chalcopyrite and quartz Richer bodies occurred at North Lyell, Comstock, and Blow open-cuts in Chocolate Shales of the Owen Conglomerate. These were followed underground.

POINTS OF SPECIAL INTEREST.

North Lyell and Old Blow: contact phenomena.
Comstock Track: Owen Conglomerate, ore bodies at Comstock, and porphyries at 621/250 and 615/250.
West Lyell: Mining operations.
Lake Margaret: Glacial phenomena and view of Henty Peneplain.
Gormanston: Varves.
Linda: Characteristic weathering of limestone, plunging folds of Lyell.
King Bridge: Porphyroid conglomerates.

REFERENCE.

Bradley, J., 1954: The Geology of the Queenstown Area. **Pap Proc. Roy. Soc. Tas. Vol. 88.**

Lower Palaeozoic Unconformities in Tasmania

By

S. Warren Carey and Maxwell R. Banks
University of Tasmania

(with 1 plate and 13 text-figures)

Abstract

Lower Palaeozoic unconformities are now known in some 29 exposures in Tasmania which are broadly equivalent to the Tyennan Unconformity of Browne. However, the time interval is found to vary and it is clear that different orogenic pulses are involved, all belonging to a general period of orogeny. The Tyennan Orogeny as defined by Browne is anomalous and requires re-definition. It is therefore proposed that the name Tyennan Orogeny be retained to mean the general orogenic period of the Cambrian as exposed in the Tyenna Valley where the Ordovician Junee Group rests on pre-Dundas strata. An unconformity between the Cambrian Dundas Group and pre-Dundas rocks is defined as the Stichtan Unconformity. An unconformity between the Junee Group and the Dundas Group is defined as the Jukesian Unconformity.

The Dundas Group has a eugeosynclinal facies with rhythmic recurrence of coarse conglomerates, breccias and greywackes, which reflect at least six orogenic pulses (as yet unnamed), all later than the Stichtan Movement and earlier than the Jukesian Movement. All eight orogenic pulses occur within the time interval of the Tyennan Unconformity, which includes the upper half of the Cambrian Period and perhaps some earlier time.

It is uncertain whether Dundas sediments were ever deposited over the regions now exposing the Tyennan Unconformity. The Jukesian regression was the most widespread emergence to be recorded in Tasmania between the Lower Cambrian and Middle Devonian Epochs.

Introduction

The report by Stephenson (this volume) of an exposure of a Lower Palaeozoic unconformity in south-west Tasmania makes it desirable to place on record some hitherto unreported exposures of similar unconformities, to examine their stratigraphic and geographic relationships, and to provide more precise nomenclature.

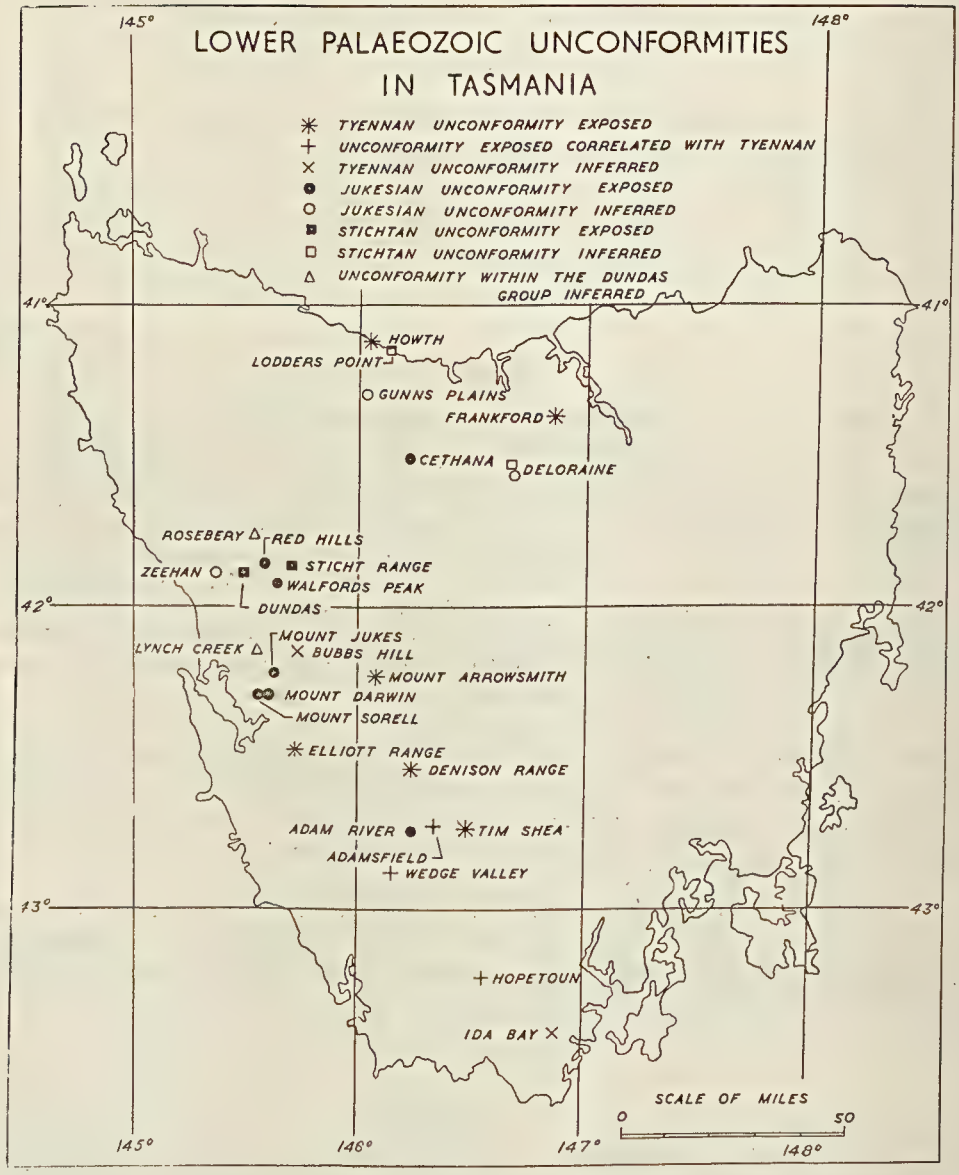

LOWER PALAEOZOIC UNCONFORMITIES
IN TASMANIA
TYENNAN UNCONFORMITY EXPOSED
UNCONFORMITY EXPOSED CORRELATED WITH TYENNAN
TYENNAN UNCONFORMITY INFERRED
JUKESIAN UNCONFORMITY EXPOSED
JUKESIAN UNCONFORMITY INFERRED
STICHTAN UNCONFORMITY EXPOSED
STICHTAN UNCONFORMITY INFERRED
UNCONFORMITY WITHIN THE DUNDAS GROUP INFERRED
145°
148°
41°
42°
43°
HOWTH
LODDERS POINT
GUNNS PLAINS
FRANKFORD
CETHANA
DELORAINE
ROSEBERY
RED HILLS
ZEEHAN
STICHT RANGE
WALFORDS PEAK
DUNDAS
LYNCH CREEK
MOUNT JUKES
BUBBS HILL
MOUNT ARROWSMITH
MOUNT DARWIN
MOUNT SORELL
ELLIOTT RANGE
DENISON RANGE
ADAM RIVER
TIM SHEA
ADAMSFIELD
WEDGE VALLEY
HOPETOUN
IDA BAY
SCALE OF MILES
0
50
145°
146°
147°
148°

FIG. 1.

Unconformity Between Junee and Dundas Groups

The first mention of possible unconformable relations between what are now known as Junee and Dundas Groups was by Officer, Balfour, and Hogg (1895, p. 122) who expressed the opinion that unconformably below the Owen Conglomerate* near Mt. Owen there was an older group of conglomerates intercalated with the schists and sandstones which are now known to belong to the Dundas Group. In the same year Montgomery (1895, p. ix) stated that near Mining Sections 106-94 (Red Hill area) conglomerate which he correlated with the Mt. Owen beds, appeared to overlie the schist formation unconformably. This relationship has recently been confirmed by one of us and is described in detail below. Later, Twelvetrees (1909, pp. 124-5) stated that the Leven Slates, &c., in the Gunns Plains district " underlie " the Ordovician limestone with unconformable angle of dip. No outcrop of the unconformity has been seen and on available evidence other interpretations are not impossible. Hills (1914) gave the first detailed description of a definite unconformity between the Junee and Dundas Groups which he mapped in the vicinity of Mt. Jukes, Mt. Darwin and Mt. Sorell; he recorded angular and metamorphic discordance between the two groups and described the presence in abundance in the Jukes Breccia (Junee Group) of pebbles and boulders derived from the " porphyroids " of the Dundas Group and from the Darwin Granite which is intrusive into the Dundas Group. Later Reid (1919, p. 25) reported similar evidence from Mt. Claude where Owen Conglomerate is unconformable on the Dundas Group and " some of the porphyroid boulders contained in the conglomerate are as much as two feet in length ". This unconformity in the Mt. Claude district has been confirmed recently by Elliston (1953, p. 1195), who cited exposures at Cethana and Bell Mount. Since the Junee Group extends down to the Canadian and the Dundas Group extends up into the Upper Cambrian, the time interval of this unconformity is the remainder of the Upper Cambrian.

Nye (1929, p. 10) reported that the West Coast Range Conglomerate of the Ragged Range rests unconformably on slates, cherts and breccias which he correlated lithologically with the Dundas Group. He stated that the lower rocks are very similar to the feldspathic breccias in the Magnet district. If Nye is correct in his correlation, then this is the same unconformity as that described by Hills. The Adam River unconformity and its relation to the unconformities at Adamsfield and Tim Shea are shown on Figs. 2 and 3.

Red Hill and Walfords Peak.

Along the West Coast Range north of Queenstown unconformable relations between the Owen Conglomerate and the Dundas Group have been mapped by one of us (M.R.B.) at Walfords Peak, Red Hill and the Gooseneck (Figs. 4 and 5). On the eastern slope of Walfords Peak a medium-grained siliceous conglomerate with thin beds of ferruginous sandstone and siltstone overlies a sheared scoriaceous biotite keratophyre.

* Owen Conglomerate is a synonym of West Coast Range Conglomerate and on grounds of priority of proper definition has now replaced the latter term (see Bradley, this volume, p. 205).

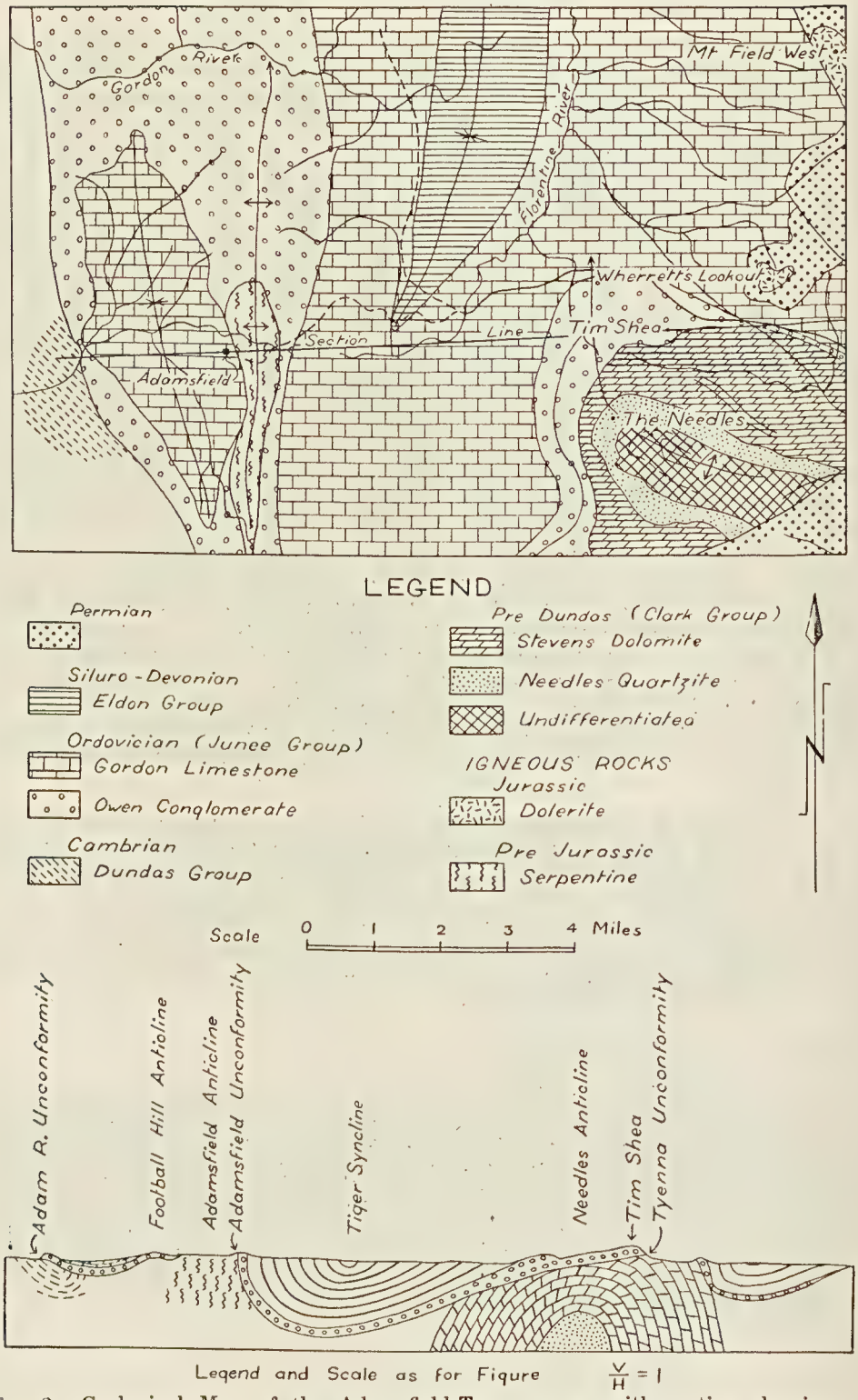
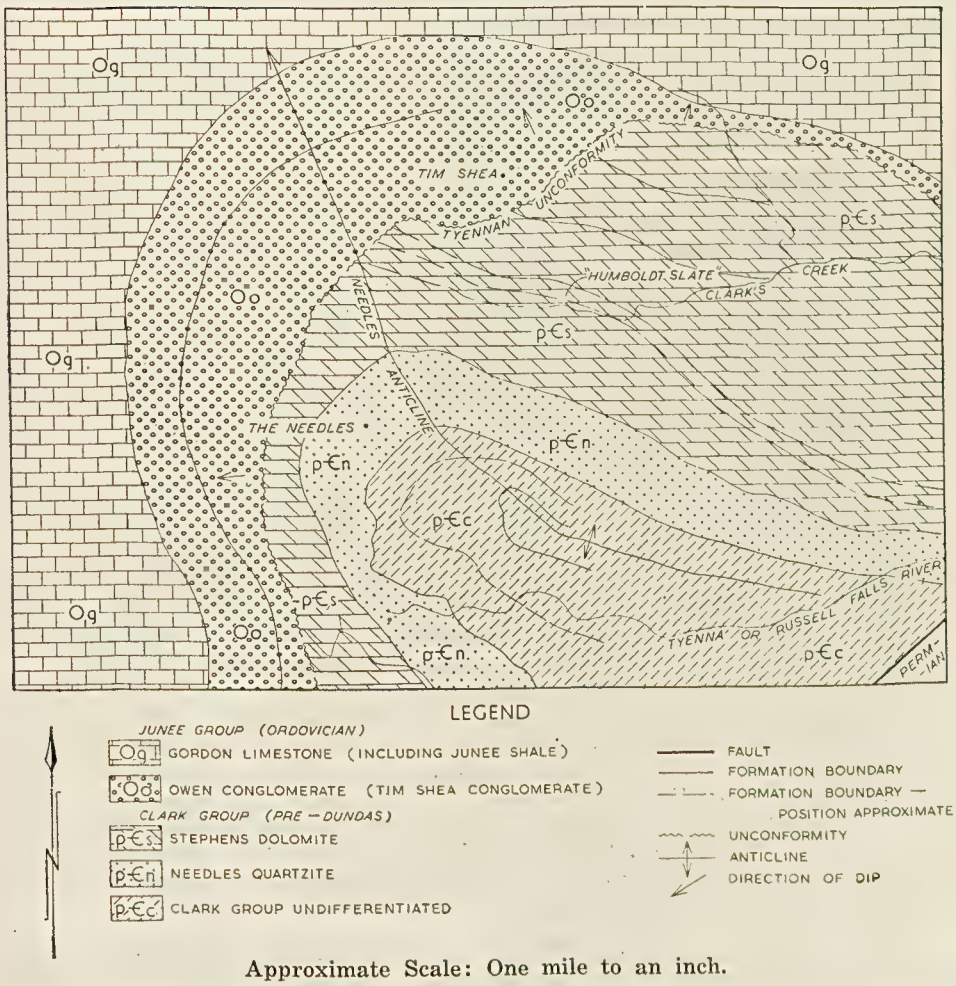


FIG. 2.—Geological Map of the Adamsfield-Tyenna area with section showing relations of Adam River, Adamsfield, and Tyenna unconformities.



Approximate Scale: One mile to an inch.

FIG. 3.—Geological sketch-map of the Needles-Tim Shea area at the head of the Tyenna valley, showing the relations of the Needles Quartzite and the Tim Shea conglomerate. Formal definitions of new formations used will be published shortly by A. H. Spry who has found that the whole section above the Needles Quartzite is largely dolomite. This includes the Humbolt "Slate" which Lewis correlated with the Dundas Group and which Spry finds to be thin-bedded dolomite.

The shear planes of the lava dip more steeply than the bedding in the conglomerate which dips about 45° to the west. The lava close to the contact is more weathered than elsewhere. The dip of the underlying sub-greywacke conglomerate is very steep to the west. There is no sign of faulting in the vicinity. On the northern foothills of Walfords Peak near Lake Rolleston the Owen Conglomerate overlies a sub-greywacke conglomerate of the Dundas Group.

A mile south of Walfords Peak, however, finely-bedded deep red sandstone and siliceous conglomerates appear to pass transitionally downwards into greywacke conglomerate and breccia with an interbedded flow of altered biotite quartz keratophyre. This section is well exposed on and eastward from a low ridge near the centre of the western shore of Lake Dora. Here, apparently, there is no unconformity between the Owen Conglomerate, represented by the quartzites and siliceous conglomerates, and the Dundas Group, represented by the greywacke breccia and lava. At Red Hill, on the western flank of Mt. Murchison, the contact between the Owen Conglomerate and Dundas Group is again revealed as an unconformity. The underlying rock is a greywacke breccia with boulders of haematite, porphyry and quartz. It is at least 150 feet thick and thought to be conformably overlain to the west by a massive pyritic keratophyre. Eastwards, however, the greywacke breccia is overlain by beds of siliceous conglomerate dipping to the east at about 30°. The basal bed of this conglomerate is extremely coarse-grained with boulders up to three feet in diameter. The conglomerate is unsorted and the boulders show little rounding. The boulders are mainly siliceous but there are a number composed of porphyries (like the keratophyres of the underlying Dundas Group) and of greywacke breccia like the underlying rock. On the eastern side of Red Hill, near the southern end, the conglomerate, still dipping east, is underlain by a scoriaceous keratophyre in which the flow lines dip steeply west. At the Gooseneck, a mile or so to the west, the conglomerate, folded into a syncline and locally dipping south, overlies a keratophyre, apparently dipping west. The basal beds of the conglomerate locally contain large boulders of the underlying keratophyre. The presence of such porphyritic boulders is also seen again in the basal beds of the conglomerate a mile north of Lake Julia. Thus, in the Red Hill area the evidence for the unconformable relations between the Dundas and Carbine Groups includes angular discordance, boulders of the older rock in the younger and the deposition of conglomerate on different beds of the Dundas Group.

Bradley (this volume, p. 227), while conceding that actual unconformity exists in some places in this area, interprets some of the evidence differently. He prefers to explain the porphyry boulders in the basal conglomerates not as evidence of Cambrian erosion of the underlying porphyries but as being due to the Devonian metasomatic porphyritization of both Cambrian rocks and similar pebbles derived from them in the immediately overlying conglomerates.

The Needles, Tyenna Valley.

Lewis (1940, p. 48) suggested the possibility of an unconformity between the quartzite forming the ridge of the Needles some two miles south-west of Tim Shea, and the slates near the Humbolt Mine under the

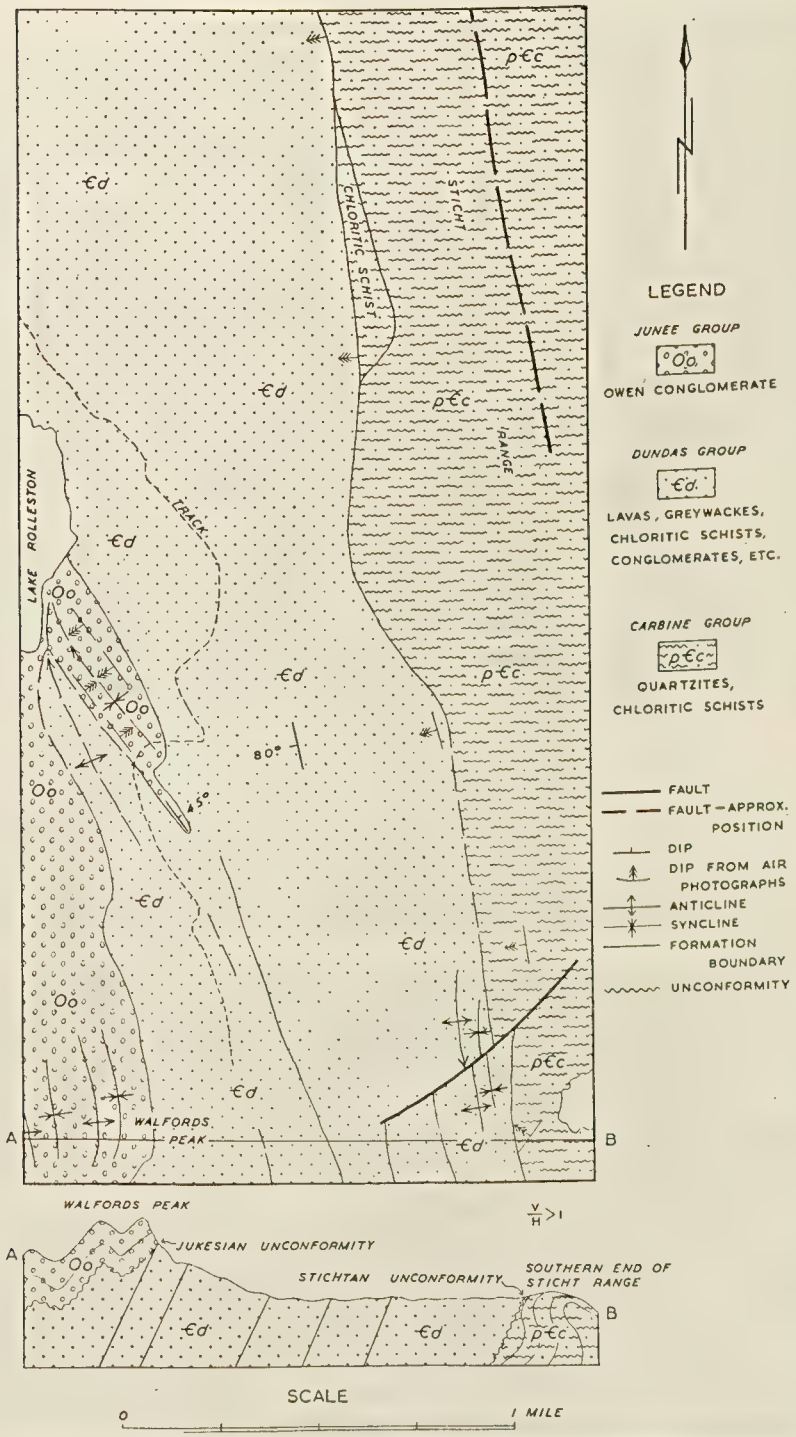


FIG. 4.—Geological map of the Walfords Peak and Sticht Range area, with section showing unconformities.

eastern shadow of the Needles. Lewis correlated (p. 47) this Needles Quartzite with the Ordovician Tim Shea Conglomerate, and the Humbolt Slate with the Cambrian Dundas Series. The unconformity appears only on a table of stratigraphic succession (p. 48) as " probable unconformity " between the " Junee Series " above and " Grey slates probably referable to the Dundas Series " below. The unconformity is not mentioned in Lewis's text and is not shown in his section through the relevant area (Plate IX, section 4). In fact, Lewis was careful to point out (p. 47) that the dip of the slate corresponds with that of the Needles Quartzite. He also stated (p. 48) that " it may be established later that the slates are of Cambrian age, but there is no justification at present for this assumption ". However, further investigation of the area has shown that (*a*) the Needles Quartzite is not correctly correlated with the Tim Shea Conglomerate but is a very much older formation, (*b*) the Humbolt Slate is not correctly correlated with the Dundas Group, and (*c*) the contact of the Needles Quartzite and Humbolt Slate is conformable (see our maps, Figs. 2 and 3). The Needles Quartzite and Humbolt Slate are both parts of a conformable sequence of pre-Dundas Group rocks which includes the thick dolomite on the south flank of Tim Shea. The alleged unconformity between Junee Group and Dundas Group in the Tyenna Valley is therefore invalidated. This is unfortunate since Browne subsequently selected this area as the type area for his Tyennan Unconformity; for although there is in fact a major unconformity beautifully exposed in the Tyenna Valley, the age and stratigraphic relations assigned by Browne to the Tyennan Unconformity do not fit it. (See discussion below under " Nomenclature ".)

Unconformity Between Junee Group and Pre-Dundas Rocks

Tim Shea.

Tim Shea, formerly known as Mt. Stephens, is a peak at the head of the Tyenna Valley on the watershed of the Florentine River. The Tim Shea unconformity seen on Fig. 5 was first reported by Twelvetrees (1908) but he referred to the upper beds as Permian. He corrected this error the next year (1909c, p. 27). The unconformity was next mentioned by Henderson (1939). The area was described by Lewis (1940, pp. 46-7, and plate VIII), but he wrongly interpreted the south-eastern escarpment of Tim Shea as the " Tim Shea Escarpment Fault " whereas this is the exposure of the unconformity. He correctly showed the conflicting strikes of the two groups of rocks but mapped both the Owen Conglomerate and the thick underlying dolomites as " quartzites and conglomerates of the Junee Group ". The unconformity here is very clear despite some talus. The crest of Tim Shea is composed of well-bedded conglomerates and quartzites of the Owen Conglomerate Formation which dip to the north-west at about 15° and form a regular cuesta. These are underlain conformably by thinly-bedded chocolate-red shales, and these by a conglomerate composed almost entirely of detritus from the under-

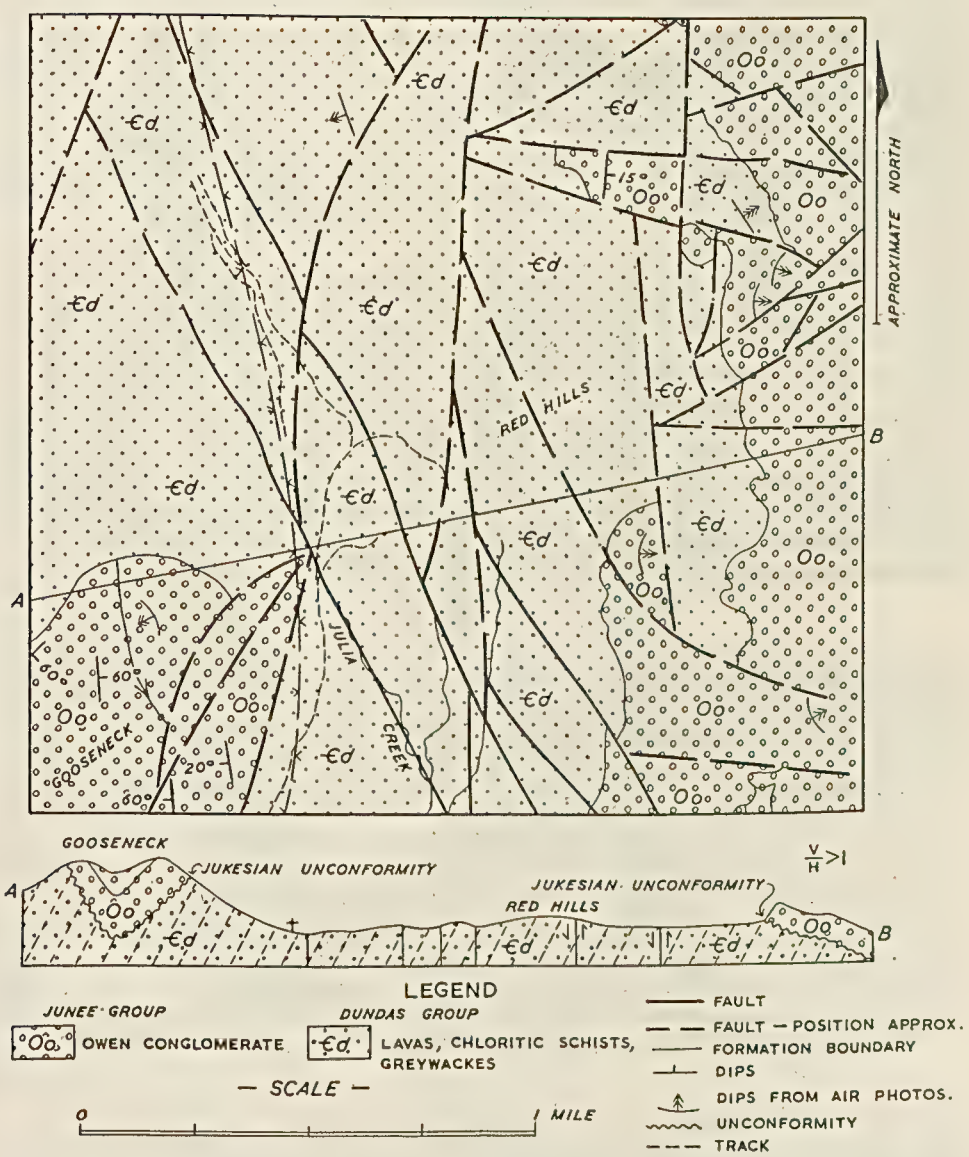


FIG. 5.—Geological map of the Red Hill area with a section from the Gooseneck to Red Hill.

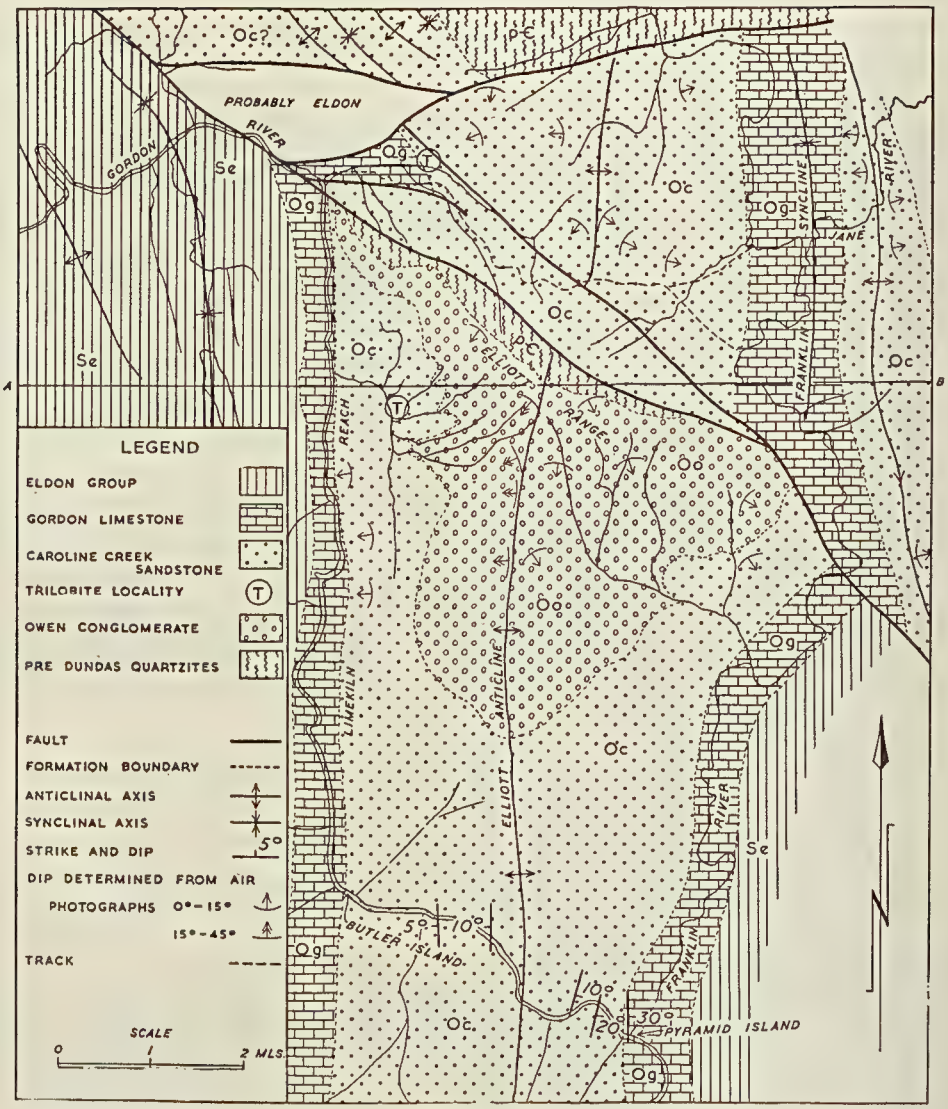


FIG. 6.—Geological Map of the Elliott Range Area, Western Tasmania.

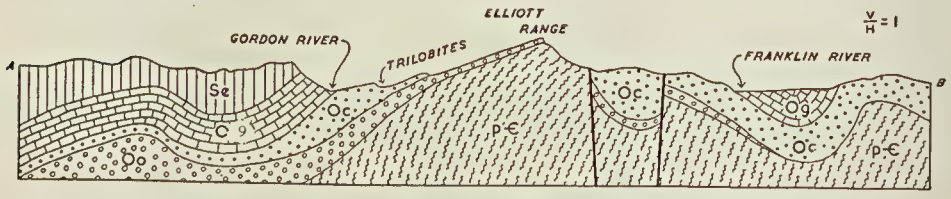


FIG. 7.—Section through Elliot Range area showing the Tyennan Unconformity (Symbols, legend and scale as for Fig. 6).

lying dolomite. The dolomite strikes north-west and dips steeply north-east. The bedding of the Junee Group is about at right angles to that of the dolomite. The dolomitic basal conglomerate of the Junee Group, being more permeable than the dolomite, is penetrated by several caves and solution channels. The age of the basal Junee Group is very early Ordovician. The age of the dolomite is not really known; it has been correlated broadly with the Smithton Dolomite on the assumption that all the pre-Dundas dolomite of Tasmania is of one age, which might well be true but is not established. The time interval of the Tim Shea unconformity includes therefore at least the greater part of the Cambrian Period up to the base of the Ordovician, and possibly also the Lower Cambrian and some of Precambrian time.

Elliott Range.

A fine unconformity on the north slopes of the Elliott Range was examined in 1951 by Mr. B. F. Glenister and one of us (S.W.C.). The unconformity can be seen clearly from a distance of two miles (see Figs. 1, 5 and 7, and Plate I, Fig. 1). The rocks below are schistose quartzites correlated lithologically with the Carbine Group. The beds above are well-bedded white quartzites and subordinate fine quartz-pebble conglomerates (Owen Conglomerate) which form the prominent cuesta of the Elliott Range. At the foot of the dip-slope they are followed conformably by highly calcareous sandstones which yielded trilobites, followed in turn by the Gordon Limestone and the Eldon Group. The Dundas Group is missing. The only previous report of this unconformity is a brief mention by one of us (Carey, 1953, p. 1112).

Bubbs Hill.

Unconformable relations may be inferred between the Junee Group and pre-Dundas strata at Bubbs Hill which rises beside the Lyell Highway on the watershed between the Nelson and Cardigan Rivers, sixteen miles east of Queenstown. The hill is crowned with siliceous sandstone belonging to the Crotty Quartzite which passes down with transition into the Gordon Limestone which dips 220° magnetic at 5°. This block is bounded on the south by a normal fault against strongly folded and contorted quartzites and schists of the Raglan Range which have been correlated generally with the Carbine Group though the Davey Group may also be present. On the north side the boundary is also a normal fault, and in the road cuttings of the Lyell Highway highly folded quartzites and schists are exposed (Fig. 8). Although no actual erosional contact between the Junee Group and older rocks is exposed, the difference in tectonic grade of the two groups is clear and an unconformity may be inferred.

Hastings and Ida Bay.

An unconformity between the Junee and Carbine Groups can also be inferred in the area between Hastings Caves and Cave Hill, Ida Bay. At Hastings, a dolomite occurs which is presumably conformable with the fine white rather saccharoidal quartzite of the Hog's Back, about half a mile to the south. This quartzite dips 65° magnetic at 53°. The dolomite and quartzite are correlated with the Carbine Group on lithological grounds. At Cave Hill, Ida Bay, a limestone of Ordovician age in part, and thus equivalent in part to the Gordon Limestone of the Junee Group, dips towards the south-west at about 6°. The base of this

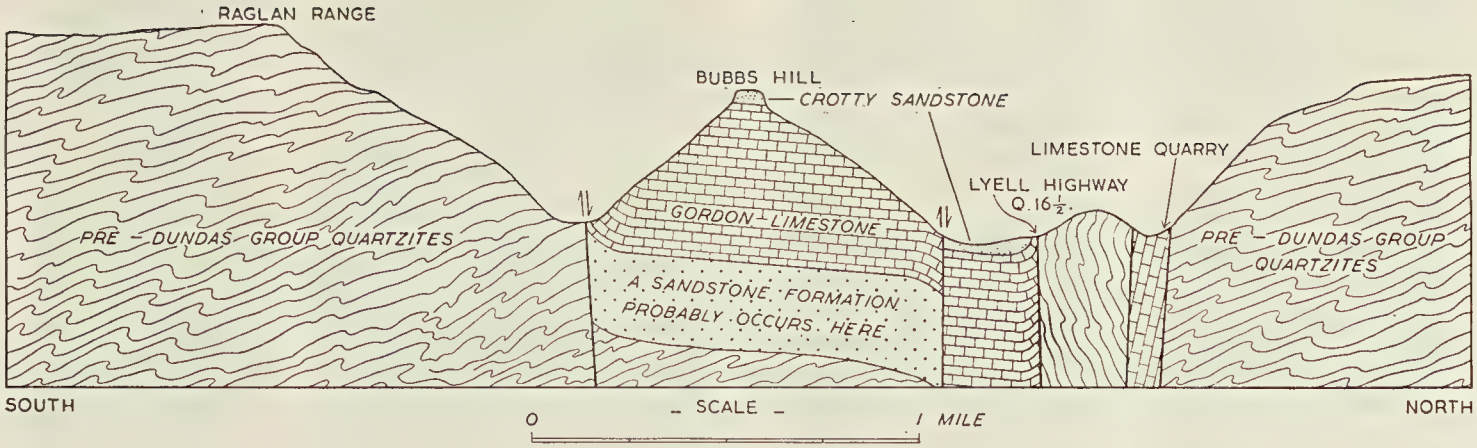


FIG. 8.—Section through Bubb's Hill and the Raglan Range, Western Tasmania.

limestone is apparently near the foot of the northern slope of Cave Hill but neither the base of the limestone nor the underlying rock has been seen. An unconformity may be inferred, however, between the Carbine and Junee Groups in this area. (See Figs. 9 and 10.)

Howth.

An unconformity with strong discordance between Owen Conglomerate and slates correlated with the Carbine Group is well exposed around the shore of a small headland between Sulphur Creek and Howth on the north coast of Tasmania (Figs. 11 and 12). The conglomerate consists of fine siliceous pebbles cemented by silica and haematite, and dips flatly landward in a gentle syncline. The rocks of the Carbine Group dip steeply.

The base of the conglomerate is irregular and a thin breccia composed of fragments of the underlying rocks forms the basal bed. Mr. A. H. Spry has found another outcrop of this unconformity just west of Penguin where the Owen Conglomerate dips westward and rests with marked angular discordance on the Carbine Group.

Frankford.

An unconformity is clearly exposed at Frankford between Owen Conglomerate and quartz schists which are provisionally referred to the Davey Group. The unconformity was first reported by Nye (1928) and was recorded by Nye and Blake (1938, p. 34).

Denison Range.

Twelvetrees (1908, p. 30) described an unconformity in the Denison Range. The upper formation, which strikes west of north, is now known to be Owen Conglomerate, and from Twelvetrees' description the lower formation, which strikes east of north, clearly belongs to the Precambrian group of quartz and mica schists. At the base of the conglomerate formation Twelvetrees described a basal breccia which corresponds with the Jukes Breccia:

> "At the junction of the two systems on the north side of the gap is a long and high crest composed of a breccia of large angular stones of quartz and quartz schist which is situated between the upper members of the schists and the basal sandstones of the conglomerate series."

Mount Arrowsmith.

An unconformity between Owen Conglomerate and Precambrian quartz and mica schists about two miles east of Mt. Arrowsmith was described by Ward (1908A, p. 37, and 1909, p. 32).

Unconformity Between Dundas and Older Groups

Unconformable relations between the Dundas Group and older rocks were first reported by Twelvetrees (1909A) at Lodders Point near Penguin. However, the contact area is covered with basalt and the unconformity is one of interpretation rather than of observation.

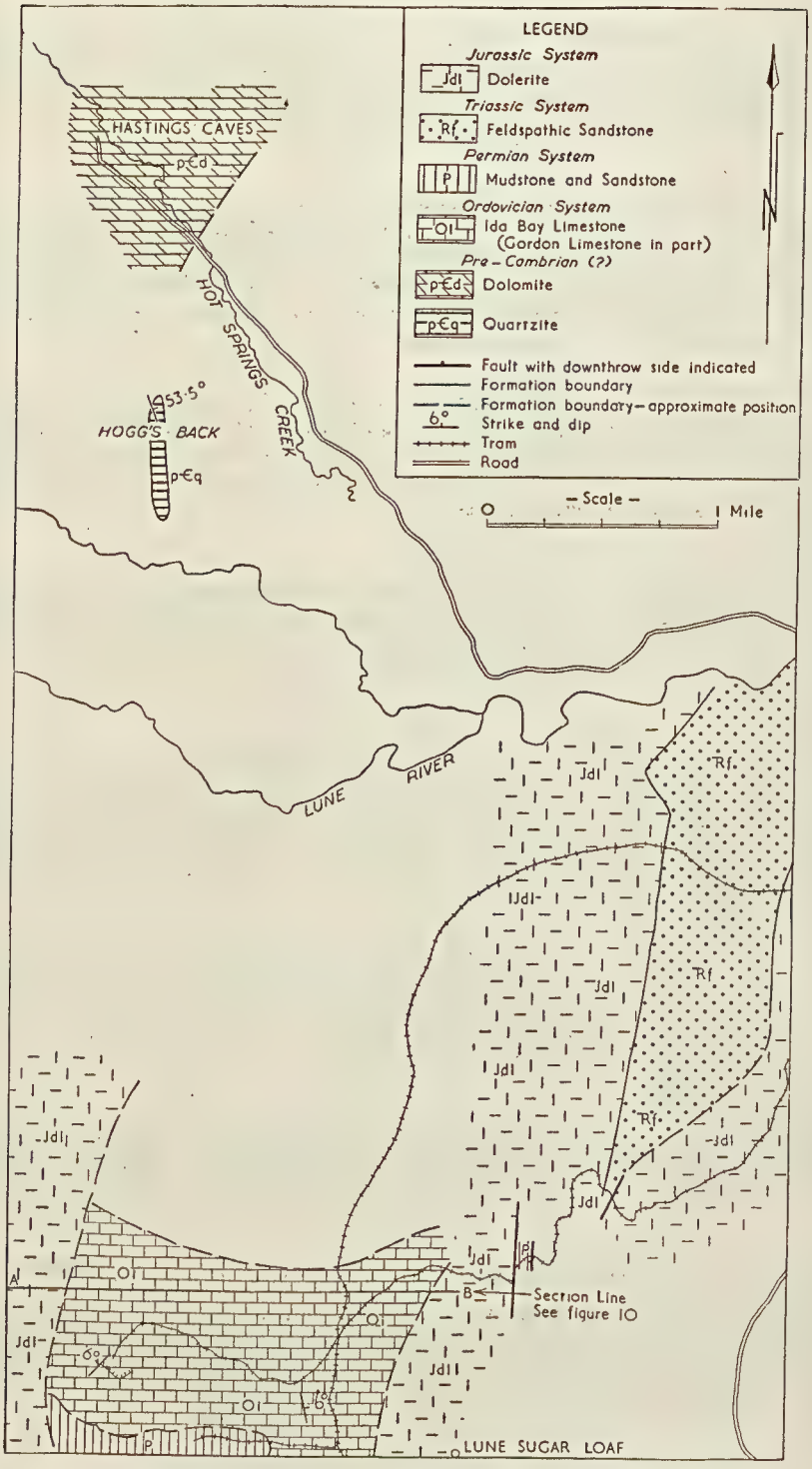


FIG. 9.—Geological map of the Ida Bay area, S.E. Tasmania.

Sticht Range.

In the Sticht Range, rocks correlated on lithological grounds with the Carbine Group at Dundas are strongly folded and overfolded to the south. The overlying Dundas Group rocks, correlated with the type area on lithological grounds, dip steeply and consistently west at 75°. The Carbine Group rocks beneath the unconformity surface are saccharoidal quartzites, black micaceous schists and glistening mica schists. The basal rocks in the Dundas Group vary along the strike. On the Sticht Range they are very coarse siliceous conglomerates with many boulders of rocks from the Carbine Group. On the southern end of the range the basal rocks of the Dundas Group are black phyllites overlain by a thin bed of limestone followed by greywackes, sub-greywackes, black slates and lavas. The presence of a lens of very coarse-grained conglomerate on the western flank of the Sticht Range suggests the presence of higher land on the pre-Dundas surface in this vicinity. The evidence for this unconformity is given on the accompanying sketch map and section (Fig. 4). The age of this unconformity can only be inferred. The age ascribed to the oldest fossils in the Dundas Group is Upper Middle Cambrian (see Elliston, this volume, p. 167) and these fossils occur in the Judith Slate and Tuff, the lowest formation in the Dundas Group in the type area. No fossils have yet been found in the Carbine Group or its correlates in any part of the State, and because of its unconformable relation to the Dundas Group it is generally considered to be Lower Cambrian or Upper Precambrian. Thus, the Stichtan Unconformity is older than Upper Middle Cambrian and extends down to an undetermined time in the Lower Cambrian or Upper Precambrian.

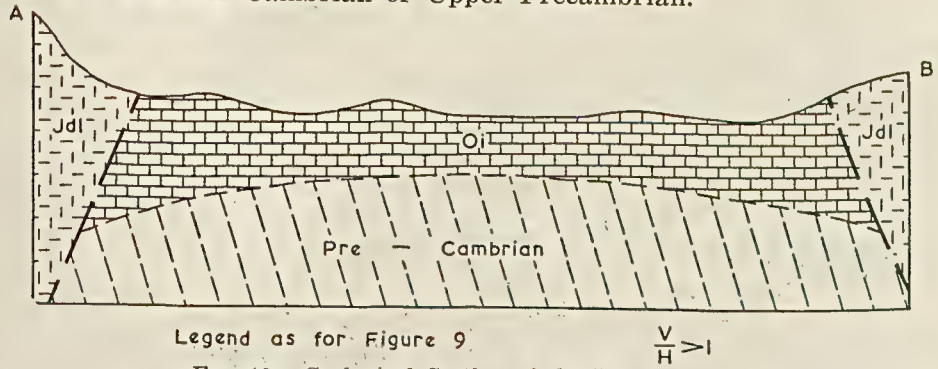


FIG. 10.—Geological Section of the Ida Bay area.

Other Areas.

Similar unconformable relations between Carbine Group and Dundas Group have been found in a number of other areas. At Dundas, Elliston (this volume, p. 174) suggests the presence of this unconformity on Wallace's Tram, on the Avon Rivulet, and on Judith Creek. On Wallace's Tram, 100 feet above the Stables, contorted slates of the Carbine Group are overlain along an irregular surface by relatively unfolded "tuff" of the Dundas Group. On the Avon Rivulet the basal Dundas "tuff" bed overlies slates in one place and quartzites in another along its strike. On Judith Creek there are marked changes in the grade of metamorphism and the direction and angle of dip between the two groups. At Deloraine,

Wells (1954) inferred an unconformity just north of the Lake Highway for several miles from Golden Valley towards Deloraine. Highly contorted and metamorphosed rocks of the Davey Group are overlain transgressively by Dundas Group sub-greywacke slates and siltstones dipping north-east at about 70°.

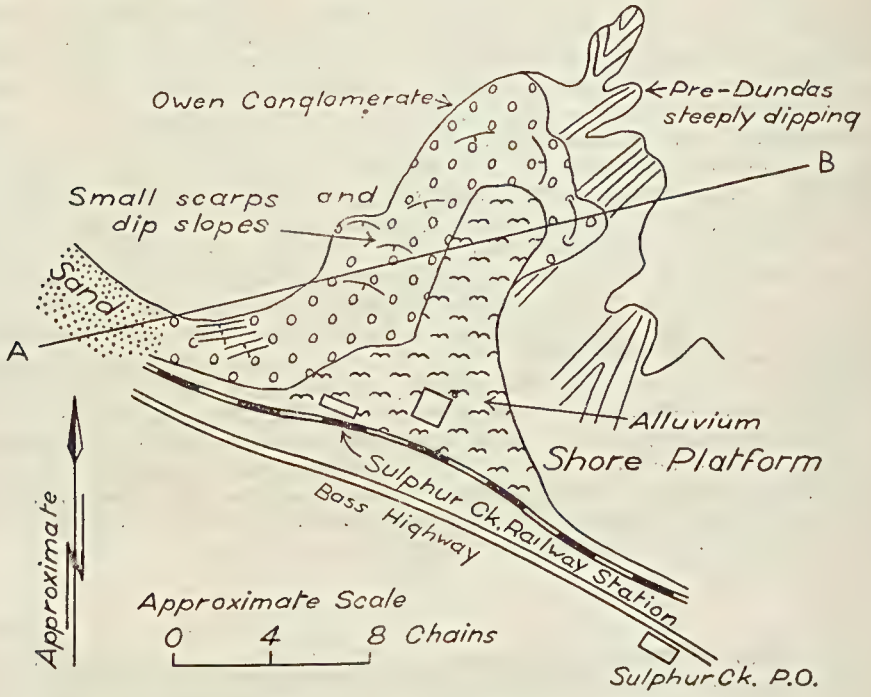


FIG. 11.—Geological Map of a headland between Sulphur Creek and Howth, N.W. Tasmania.

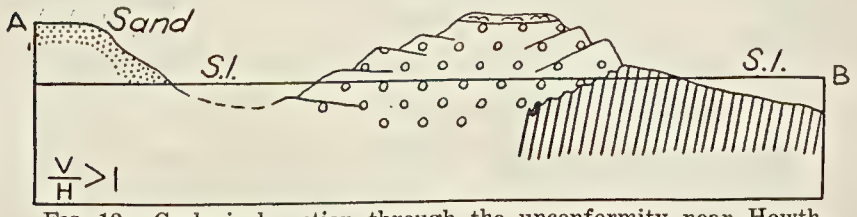


FIG. 12.—Geological section through the unconformity near Howth.

UNCONFORMITIES WITHIN THE DUNDAS GROUP

Lynch Creek.

Bradley (this volume, p. 221) has inferred an unconformity between the Lynch Conglomerate and the Miners Slate. Both these formations are considered by us to be correlates of parts of the Dundas Group as defined by Elliston (this volume).

Rosebery.

Graham Hall and Cottle (1953, p. 1146) stated that at Rosebery there is structural discordance in addition to faulting between a younger formation referred to as " massive pyroclastics " and an older sedimentary formation. The pyroclastic formation, which consists of agglomerates, tuffs and lavas, is regarded by Elliston (this volume) as part of his Dundas Group, a correlation which we accept. The older formation is probably Dundas Group also. The implied unconformity would therefore be within the Dundas Group.

Unconformities Between Junee Group and Rocks of Uncertain Age

Mt. Hopetoun.

Stephenson has recorded an unconformity in the vicinity of Mt. Hopetoun in the Cracroft River Valley (this volume, p. 151, and plate I, fig. 1). The upper formation, from his description and photograph, fits exactly the facies of the Owen Conglomerate which might be expected in this area. It closely resembles the occurrence on the Elliott Range. The lower formation of quartz schists and mica schists closely fits the Davey Group. It could scarcely be the Dundas Group, though the Carbine Group cannot be wholly excluded. This unconformity can therefore be correlated with some confidence with the unconformities between Junee Group and pre-Dundas Group rocks.

Wedge Valley.

Twelvetrees (1909b, p. 29) inferred unconformable relations between Precambrian schists and quartzites, slates and conglomerates, which he described as " Cambrian ", in the Wedge River Valley about four miles north-west of Mt. Wedge. Twelvetrees used the word Cambrian to include what is now accepted as lower Ordovician (e.g., Tremadoc, &c.), and his map includes in the Cambrian the whole of the Owen Conglomerate and Florentine Valley shales now known to be Ordovician Junee Group. This unconformity is therefore provisionally correlated with the unconformities between Junee Group and pre-Dundas Group rocks.

Adamsfield.

The contact between serpentine and Owen Conglomerate at the head of Main Creek at Adamsfield was originally described as a fault (Nye, 1929, p. 17). The actual contact zone has been mined for some years in the past for osmiridium, first by open cut and subsequently by stopes. In 1943 Thomas collected trilobites from dark-green shales immediately overlying the stoped zone. The outcrop was visited in 1952 by a party consisting of Dr. O. P. Singleton, Mr. B. F. Glenister, Miss E. M. Smith and one of the present authors (S.W.C.). More trilobite fragments were collected from the shales. Examination of the exposure revealed the fact that the contact is not a fault but an unconformity. Overlying the serpentine is a conglomerate made up entirely of pebbles of serpentine in a matrix also consisting largely of serpentine detritus. Although somewhat masked by crushing, careful scrutiny reveals that the whole deposit

is bedded, with grainsize varying down to that of the trilobite-bearing shales which also appear to be made up largely of serpentine detritus. There are sedimentary concentrations of magnetite and what appears to be chromite. The osmiridium occurs as detritus in the basal conglomerate. The lode is therefore a placer deposit, probably marine, since trilobites are present a few feet above.

These basal beds, derived from the disintegration of the underlying serpentine, are followed conformably by the Owen Conglomerate and then again conformably by the Gordon Limestone and the Eldon Group. The map and section Fig. 2 show the structural relations of the Tim Shea, Adamsfield and Adam River unconformities. One of the facts which led Nye to the fault interpretation was the great reduction in thickness of the Owen Conglomerate southwards from The Thumbs to the workings at the head of Main Creek. However, this is now known to be due to depositional lensing of the conglomerate in which such thickness variation is not uncommon.

The recognition of this unconformity has two important corollaries. In the first place, the osmiridium occurrence at the head of Main Creek has been quoted as a primary lode (e.g., Elliston, 1953, p. 1253) whereas it is now shown to be a placer. In the second place, the serpentine has been regarded as a Devonian intrusion whereas now it is shown to be pre-Ordovician.

The lower limit of the age of the serpentine is still uncertain. If it is to be correlated with the serpentine at Dundas, as seems reasonable, then it is probably late Middle Cambrian or Upper Cambrian (see Elliston, this volume, p. 172). This would imply that the time break for the Adamsfield unconformity was not longer than the Upper Cambrian, and that the unconformity belongs to the group of unconformities between the Dundas and Junee Groups.

Nomenclature

From the foregoing descriptions it is clear that at least three kinds of unconformable relations occur in the Lower Palaeozoic rocks of Tasmania: (1) between Junee Group and Dundas Group; (2) between Junee Group and pre-Dundas Group rocks; (3) between Dundas Group and pre-Dundas Group rocks. These unconformities imply orogenic movements within the Upper Cambrian, within the Cambrian Period or late Precambrian, and within the Lower Cambrian or late Precambrian respectively. In addition, there is Bradley's inferred unconformity between the Lynch Conglomerate and Miners Slate within the Dundas Group. Complementary information is provided by the sediments of the Dundas Group, which is largely developed in a eugeosynclinal tectofacies, with a rhythmic repetition of coarse conglomerates, breccias and greywackes on the one hand, alternating with slates and fine-grained tuffs on the other (Elliston, this volume, p. 165). This sequence of orogenic sediments, if they have been correctly interpreted, implies at least six orogenic pulses during the Middle and early Upper Cambrian, that is, between the earliest and latest movements implied by the unconformities. In order to be precise in our nomenclature and thinking, it is therefore necessary to use ultimately separate names for each of the eight Cambrian

orogenic movements indicated. In addition, a general group name is required to refer to the broad period of orogenesis which is seen to have recurred throughout most of the Cambrian Period.

Tyennan Orogeny.

The only existing name is the Tyennan Orogeny of Browne (1949, p. 38) which he uses with Australia-wide application and has defined as follows: " it is not until we reach the upper part of the Cambrian sequence that we meet the next big orogenic hiatus. In Tasmania this is well marked in the neighbourhood of Adamsfield and in the Tyenna Valley (Fig. 3) [Browne's Fig. 3 is reproduced here as Fig. 13], hence we may perhaps call the movement to which it is related the Tyennan. The Dundas Series of Middle to (?) Lower Cambrian age is said to be overlain with strong unconformity by the Junee Series of heavy conglomerates which pass up into sandstone, overlain by shales containing lowest Ordovician and Canadian fossils. Since this series contains 2000 feet of strata below the shales, we may fairly assume that the conglomerates descend to the Upper Cambrian, and that the Tyennan Orogeny is fairly widespread in Central and Western Tasmania."

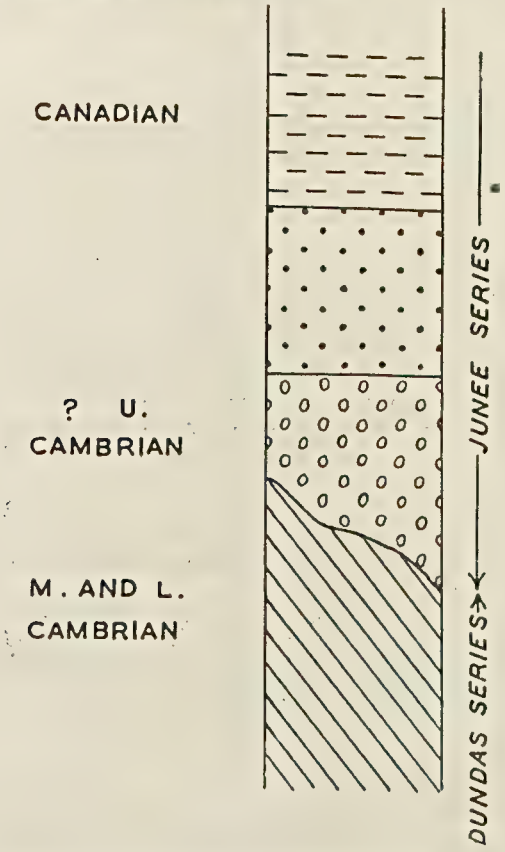


FIG. 13.—The Tyennan Unconformity of Browne.

The base of the conglomerates is now known to be Lower Ordovician so that Browne's definition would need to be revised as the orogeny between the Middle Cambrian and Lower Ordovician. Apart from this adjustment, the definition as it stands is anomalous. For it is clear from Browne's text and figure that his Tyennan Orogeny refers to an orogeny involving the Middle Cambrian Dundas Group. However, no Dundas Group rocks are known from the Tyenna Valley, and the unconformity which is beautifully exposed at Tim Shea at the head of the Tyenna Valley, and which fits Browne's figure except for the age of the lower group, is between Junee Group rocks and thick dolomites which are certainly pre-Dundas. What then is the Tyennan Unconformity? If it is the pre-Junee unconformity exposed in the Tyenna Valley, then it belongs to the first group of unconformities above described. If, however, it is the unconformity between the Junee and Dundas Groups, then it belongs to the second group of unconformities described. Since a choice has to be made or the name has to be dropped altogether, we propose to redefine the Tyennan Unconformity as the unconformity exposed at the head of the Tyenna Valley. This course preserves for Tyennan Unconformity the meaning it might be expected to have, and permits the Junee-Dundas unconformity to be named after the Jukes-Darwin area where it was first recognised and described.

Tyennan Unconformity (*revised definition*).

The Tyennan Unconformity may be defined as the angular discordance between pre-Dundas rocks below and the Junee Group above as revealed on the south-eastern slope of Tim Shea, at the head of the Tyenna Valley. Stratigraphically the Tyennan Unconformity may be considered as the erosional surface of pre-Dundas rocks on which the Junee Group was deposited. The Jukesian surface, to be defined below, will be the continuation of this surface where Dundas Group rocks were present. The Stichtan surface, also to be defined below, will intersect the Tyennan and Jukesian surfaces. From the tectonic viewpoint, this unconformity may be considered as the expression of eight or more orogenic movements, the earliest being older than Upper Middle Cambrian and the latest being younger than lower Upper Cambrian but older than Lower Ordovician, together with a period of erosion or non-deposition prior to the deposition of the Junee Group. The orogenic movements occurring within the span of time represented by the Tyennan Unconformity may be referred to as the Tyennan Orogeny. This span of time is at least that during which the Dundas Group was deposited. The lowest formation of this Group at Dundas contains trilobites, indicating (Opik, 1951A) an horizon near the base of the Upper Middle Cambrian, and the youngest fossils so far recognised in the Group are trilobites from the Huskisson River and Leven Gorge indicating an horizon near the top of the lower Upper Cambrian (Opik, 1951B). The fossils in the Owen Conglomerate indicate Lower Canadian age (Opik, 1951A) so that the last pulse of the Tyennan Orogeny must be older than this.

Stichtan Unconformity (*definition*).

The Stichtan Unconformity may be defined as the angular discordance between the Carbine Group below and the Dundas Group above as revealed on the western flank of the Sticht Range and its southern

continuation to a point east of Lake Dora in the West Coast Range. Stratigraphically, the Stichtan Unconformity may be considered as the erosional surface on which the Dundas Group was deposited. From the tectonic viewpoint, on the other hand, this unconformity may be considered as the expression of an orogenic movement of pre-Upper Middle Cambrian age, followed by a period of erosion or non-deposition prior to the deposition of the Dundas Group. This orogenic movement may be referred to as the Stichtan Movement of the Tyennan Orogeny.

Jukesian Unconformity (definition).

The Jukesian Unconformity may be defined as the angular discordance between the Dundas Group below and the Junee Group above as revealed at the northern end of Mt. Jukes, south of Queenstown. Hills (1913) was the first author to identify unambiguously and describe an unconformity between what are now known as the Junee and Dundas Groups. It is therefore appropriate that the type section for this unconformity should be chosen from the Jukes-Darwin area and in particular the exposure which Hills considered (p. 45) to be the best exposure of the unconformity. Stratigraphically the Jukesian Unconformity may be considered as the erosional surface of Dundas Group on which the Junee Group was deposited. From the tectonic viewpoint this unconformity may be considered as the expression of an orogenic movement of post-Lower Upper Cambrian but pre-Lower Ordovician age followed by a period of erosion or non-deposition prior to the deposition of the Junee Group. This orogenic movement may be referred to as the Jukesian Movement of the Tyennan Orogeny.

Movements within the Dundas Group.

Six orogenic movements have been inferred within the Dundas Group, and actual angular discordance has been inferred on Lynch Creek. However, we do not at this stage propose any formal nomenclature. This might be deferred until an objective exposure can be cited as the type area for the name. Meanwhile, the name of a particular orogenic formation within the Dundas Group might be used to specify any such inferred movement.

Palaeogeographic Implications

Limits of Cambrian Sedimentation.

In discussing palaeogeography we shall speak of Stichtan, Jukesian and Tyennan areas as meaning those areas in which those respective types of unconformity are now found.

It is clear at the outset that the Jukesian areas received Dundas sedimentation, followed by the Jukesian Movement and erosion before the Junee transgression. It is not clear, however, whether Dundas sediments were ever deposited on the Tyennan areas. Two interpretations are possible. (*a*) The Tyennan areas were emergent belts during the

Dundas sedimentation, supplying sediment to the intervening Dundas trough, which was folded during the Jukesian Movement and eroded so that a common surface was established over the Tyennan, Jukesian and non-folded Dundas areas, on which the Junee Group was deposited. (*b*) The Tyennan areas received Dundas sedimentation, perhaps in reduced thickness, but were uplifted more strongly during the Jukesian Movement than the Jukesian areas, so that the whole of the Dundas sediment was stripped off and the underlying pre-Dundas rocks exposed. The following considerations bear on this question:

(1) The Dundas sedimentation thins rapidly towards the Tyennan areas. This is noticeable south of Deloraine, eastwards from Mt. Farrell, and across the King Syncline. The impression gained is of depositional thinning rather than erosional thinning though evidence is not conclusive on this point. This would favour the first alternative.

(2) The Dundas Group contains basic lavas and ultrabasic intrusives which appear to be cognate. Such ultrabasic rocks are normally correlated with active geosynclines and are not normally associated with cratonic areas. If this theory is adopted and the numerous serpentinites in Tasmania are regarded as of Cambrian age and as originally intrusive into Dundas sediments, then the area of Dundas sedimentation would be greatly extended and any cratonic geanticlines of non-deposition would be narrow. This interpretation would favour the second alternative, but the theoretical assumptions involved are open to challenge.

Jukesian Regression and Junee Transgression.

The Jukesian and Tyennan Unconformities imply a widespread regression during the Upper Cambrian followed by erosion and then a transgression over much of the eroded surface. What happened east of the meridan of Hobart is not yet clear, as the older rocks are either covered by younger sediments or exposed in the north-east where the facies is likely to be different and little detailed work has been done.

Both the Jukesian and Tyennan areas were subjected to erosion during at least part of the Upper Cambrian. The youngest fossils so far found in the Dundas Group belong to the top of the lower part of the Upper Cambrian. The beds in which these occur are not the topmost beds in the Group so that the age of the youngest beds involved in the Jukesian Movement is uncertain although certainly pre-Ordovician. However, some time during the Upper Cambrian the sea withdrew from the region in the most extensive regression between the Lower Cambrian and the Middle Devonian.

After an interval of erosion following the Jukesian Movement, deposition began in the Lower Ordovician in a transgressive sea which had spread by Upper Ordovician time at least as far north-west as Heazlewood, as far west as Eden and as far south as New River.

Hills and Carey (1949, p. 25) pointed out that the basal formation of this transgressive group is commonly a greywacke breccia or conglomerate consisting of blocks of rock derived from the immediately adjacent basement—the Jukes Breccia. Thus, at Mt. Darwin and Mt. Sorell the breccia is rich in blocks of Darwin Granite and locally derived " porphyroids ", at Adamsfield overlying a serpentine basement it is composed largely of detrital serpentine, at Tim Shea overlying a dolomite basement, it is composed almost entirely of boulders of dolomite and in the Denison Range overlying quartz schists it is composed of similar rocks. Commonly, however, where the underlying rock is quartzite or quartz schist as at Frankford, Elliott Range and near Mt. Hopetoun, the Jukes Breccia seems to be missing and the total thickness of the conglomerate less. Moreover, the Jukes Breccia always passes up into Owen Conglomerate which is composed for the most part of pebbles of quartzite, quartz schist, vein quartz and chert. This conglomerate shows no correlation with the type of underlying basement.

The varying composition and the texture of the Jukes Breccia indicate that the landscape that was being buried was geologically varied and that there was considerable relief. In addition, rapid initial sinking of the floor of deposition is implied. As the rate of sinking decreased the Jukes Breccia type of sediment was followed upwards by the sandy and conglomeratic sediments of the Owen Conglomerate, indicating, by the degree of rounding of hard rocks and the complete absence of weak rocks, considerable transport or re-working before deposition. The rapid thinning characteristic of the conglomerates combined with well developed undisturbed bedding suggest that prolonged re-working near shorelines rather than long transport was the principal factor. These facts, combined with the wide area through which the conglomerates recur with surprising uniformity of lithology, suggest the presence of a number of islands in the early Ordovician sea. These necessarily all contained outcrops of quartzite, quartz schist and probably chert. However, the absence of pebbles of weaker rocks such as serpentine, slate, " porphyroids ", dolomite and mica schist which occur in the Jukes Breccia, could mean that these softer rocks formed only the lower relief on the Jukesian landscape and hence were the first to be buried by the rising tide of Junee sedimentation. However, even if the last-surviving islands still exposed such rocks, perhaps even in dominance, the weaker rocks would scarcely be expected to have survived the severe attrition indicated by the highly rounded quartzite pebbles of the conglomerate. The absence of " porphyroids " and other such rocks from the pebbles of the Owen Conglomerate has already been discussed by Ward (1908B, pp. 26-7) and Hills (1913, pp. 58-9). Both these authors suggested the early covering of the Dundas Group rocks; but whereas this is a possible explanation it is clearly not necessarily the correct one.

As the last-surviving islands and the main cratonic area were reduced, the Owen Conglomerate passed upwards into the Caroline Creek Sandstone and this into the Gordon Limestone by which time the islands had probably disappeared and the craton was approaching a peneplain.

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Locality Index

	Quadrangle	Latitude	Longitude
Adam River	Huntly 73	42° 44′	146° 16′
Adamsfield	Huntly 73	42° 44′	146° 20′
Avon Rivulet	Zeehan 50	41° 50′	145° 27′
Bell Mount	Sheffield 37	41° 27′	146° 06′
Bubb's Hill	Lyell 58	42° 07′	145° 45′
Cardigan R.	Lyell 58	42° 08′	145° 49′
Cave Hill	Adamson 93	43° 27′	146° 52′
Cethana	Sheffield 37	41° 28′	146° 10′
Cracroft R.	Arthur 86	43° 10′	146° 28′
Deloraine	Quamby 46	41° 31′	146° 40′
Denison Range	Huntly 73	42° 34′	146° 17′
Dundas	Zeehan 50	42° 53′	145° 24′
Eden Siding	Zeehan 50	41° 59′	145° 18′
Elliott Range	Pillinger 65	42° 30′	145° 42′
Florentine R.	Huntly 73	42° 35′	146° 30′
Frankford	Frankford 38	41° 19′	146° 45′
Golden Valley	Quamby 46	41° 37′	146° 43′
Gooseneck	Murchison 51	41° 52′	145° 33′
Gunns Plains	Sheffield 37	41° 18′	146° 01′
Hastings Caves	Adamson 93	43° 24′	146° 53′
Heazlewood	Magnet 35	41° 30′	145° 18′
Hog's Back	Adamson 93	43° 24′	146° 52′
Howth	Devonport 29	41° 05′	146° 01′
Humbolt Mine	Styx 81	42° 45′	146° 30′
Huskisson R.	Corinna 43	41° 39′	145° 27′
Ida Bay (district)	Adamson 93	43° 27′	146° 54′
Judith Creek	Zeehan 50	41° 54′	145° 28′
Lake Dora	Murchison 51	41° 58′	145° 39′
Lake Julia	Murchison 51	41° 54′	145° 34′
Lake Rolleston	Murchison 51	41° 55′	145° 37′
Leven Gorge	Devonport 29	41° 15′	146° 10′
Lodders Point	Devonport 29	41° 07′	146° 08′
Magnet	Magnet 35	41° 28′	145° 26′
Main Creek	Huntly 73	42° 44′	146° 20′
Mount Arrowsmith	St. Clair 59	42° 12′	146° 04′
Mount Claude	Sheffield 37	41° 30′	146° 12′
Mount Darwin	Lyell 58	42° 16′	145° 36′
Mount Farrell	Mackintosh 44	41° 44′	145° 34′
Mount Hopetoun	Picton 87	43° 13′	146° 31′
Mount Jukes	Lyell 58	42° 11′	145° 36′
Mount Murchison	Murchison 51	41° 50′	145° 36′
Mount Sorell	Pillinger 65	42° 15′	145° 32′
Mount Wedge	Pedder 80	42° 50′	146° 17′
Needles	Huntly 73	42° 44′	146° 28′
Nelson R.	Lyell 58	42° 07′	145° 43′
New River	Adamson 93	43° 27′	146° 35′
Penguin	Devonport 29	41° 07′	146° 03′
Ragged Range	Pedder 80	42° 46′	146° 16′
Raglan Range	Lyell 58	42° 08′	145° 46′
Red Hill	Murchison 51	41° 52′	145° 35′
Rosebery	Murchison 51	42° 48′	145° 32′
Stables	Zeehan 50	42° 53′	145° 24′
Sticht Range	Murchison 51	41° 52′	145° 38′
Sulphur Creek	Devonport 29	41° 07′	146° 02′
Thumbs	Huntly 73	42° 41′	146° 20′
Tim Shea	Huntly 73	42° 43′	146° 29′
Tyenna Valley	Huntly 73	42° 44′	146° 30′
Walfords Peak	Murchison 51	41° 56′	145° 48′
Wallace's Tram	Zeehan 50	42° 50′	145° 26′
Wedge River	Huntly 73	42° 45′	146° 11′

Plate I, Fig. 1.—Unconformity between Owen Conglomerate and pre-Dundas Group quartzites, Elliott Range, W. Tasmania. (Photo. by B. Glenister)

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Native Copper at Smithton—A Correction

By

S. Warren Carey and Beryl Scott

In a recent paper (Carey & Scott, 1952) in which the geology of the Smithton district was revised in several respects, we stated (p. 67) that a mineral occurring in the Smithton basalt, previously described by Nye, Finucane, and Blake (1934), as native copper had been wrongly determined and was pyrrhotite. Shortly after this paper appeared, Dr. A. B. Edwards, suspecting the possible presence of heazlewoodite, requested a sample of the rock, and we sent him a sample No. 5075 from Coward's Road, Smithton, a basalt containing megascopic clots of the coppery mineral.

After examination of the mineral Dr. Edwards wrote as follows: "The mineral resembling native copper is native copper. The appearance in polished section is typical, the mineral effervesces when etched with 1 : 1 nitric acid, and the etch drop gives a strongly positive test for copper when potassium mercuric thiocyanate is added to it. So that there should be no mistake, I had Dr. McAndrew take an X-ray diffraction pattern of the mineral, and it is undoubtedly native copper."

The determination of pyrrhotite had been based on a negative chemical test for copper and a positive magnetic test, together with a number of bits of suggestive evidence. In the absence of one of us (B.S.) who is now residing abroad, and of the other (S.W.C.), who has been away from Tasmania since Dr. Edwards' communication, Mr. R. J. Ford has, at our request, checked the field outcrops and repeated the original tests, and reports as follows:

(1) The mineral determined by Dr. Edwards is the same mineral as that previously described. There is no question of the occurrence of pyrrhotite and native copper in separate outcrops.

(2) The previous negative chemical tests for copper were in error in that an excess of potassium iodide had prevented the formation of a precipitate of cuprous iodide.

(3) The previous magnetic test was in error in that microscopic examination reveals that much of the native copper is finely intergrown with magnetite, which resulted in apparent magnetic separation of the coppery mineral.

(4) The mineral dissolves readily in dilute nitric acid to give a faint blue solution which on evaporation leaves blue-green crystals as well as a brownish residue of iron. The residue is taken up with dilute HCl. The addition of potassium iodide solution produces a white precipitate of cuprous iodide, tinged brown by iodine liberated by the acid conditions.

Hence there can be no doubt that the original determination of native copper was correct. We are grateful to Dr. Edwards for drawing our attention to our error.

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Additional Discoveries of Aboriginal Rock Carvings in Tasmania

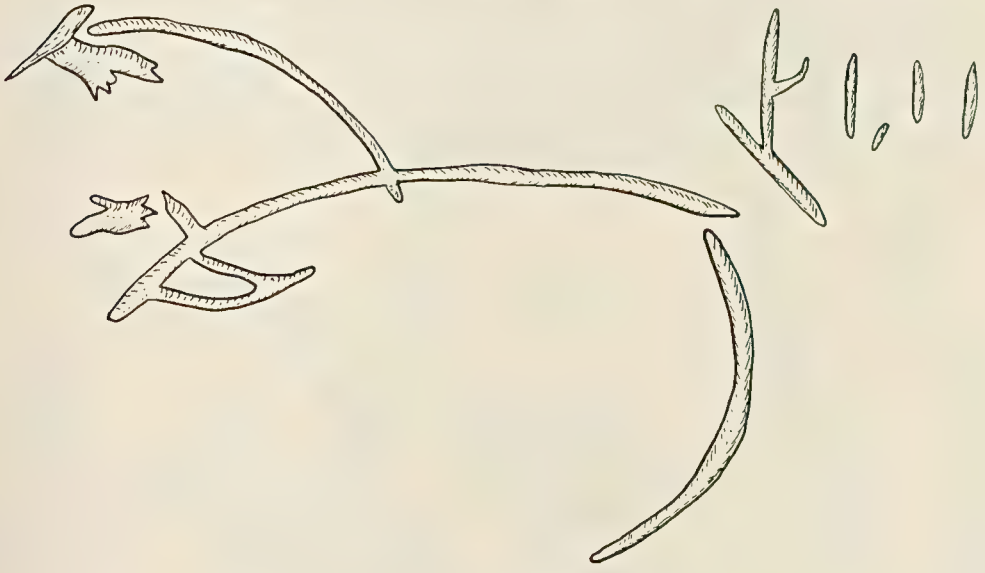
By

Owen W. Reid

(WITH 9 FIGURES)

In 1949 Mr. A. L. Meston informed me of the existence of aboriginal rock carvings near Nubeena on Tasman's Peninsula. He had visited the site some years earlier but had not been able to revisit them. As he had mis-laid his chart, only an approximate location could be given.

After several visits to the area rock workings were found on the southern slope of a high dolerite ridge known locally as "Billy Blue". They were on a large sand-stone rock measuring approximately sixty yards long and four yards wide. It faced west and was on the eastern bank of a creek bed which, though normally dry, has a permanent soakage at its mouth some fifty yards below the carved rock. At a distance of fifteen yards seawards from the main rock surface is a smaller one measuring about twenty feet square which has several carved figures on its upper surface. Some of these resemble kangaroo tracks while others are leaf-like depressions up to ten inches in length.



Rock Engravings Near Nubeena

Fig. 1.—The parabola as the main motif. The large one in the middle is four feet in length with the remainder on the same scale.

Extending over an area of some ten acres to the south east of the outcrop remains of shells are scattered. Here a considerable number of stone artefacts have been found. This flat area, now overgrown with bracken, heath, eucalypts and casurinas, would have provided a suitable ceremonial ground.

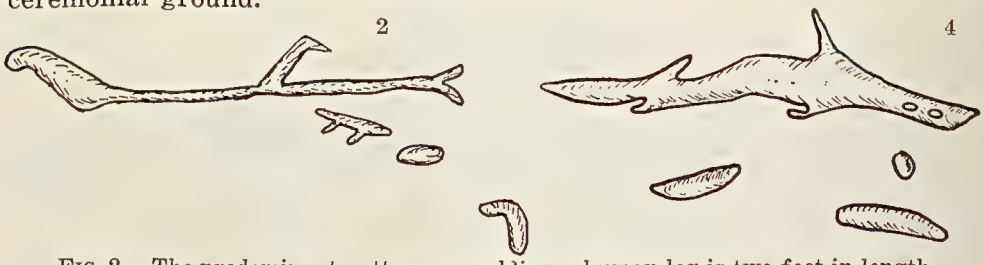


FIG. 2.—The predominant pattern resembling a human leg is two feet in length.
FIG. 4.—The main figure, bearing a likeness to a blue-tongued lizard has a length of twenty inches.

The standstone outcrop would have provided an easy working medium. Some of the patterns are being lost, as parts of the surface split off or are denuded by weathering. Like the majority of aboriginal rock workings the significance of the designs is obscure. They may be said to be archaeolithic. In the main group the chief motif is parabolic in form. Across the middle of the sloping worked face and connecting two heavily worked areas is an almost semi-circular depression four feet in length and varying in width from one and a half inches to two inches and from a half to two inches in depth. At right angles to its northern extremity is a similar shape three feet in length. Adjoining it one well worked pattern resembles a sting-ray with a well-finished tail-piece. Another clearly defined figure gives the impression of a human leg. Other designs bear a likeness to a young moon, to animal or bird tracks—kangaroo, wombat or emu—men in a canoe, snakes, &c.

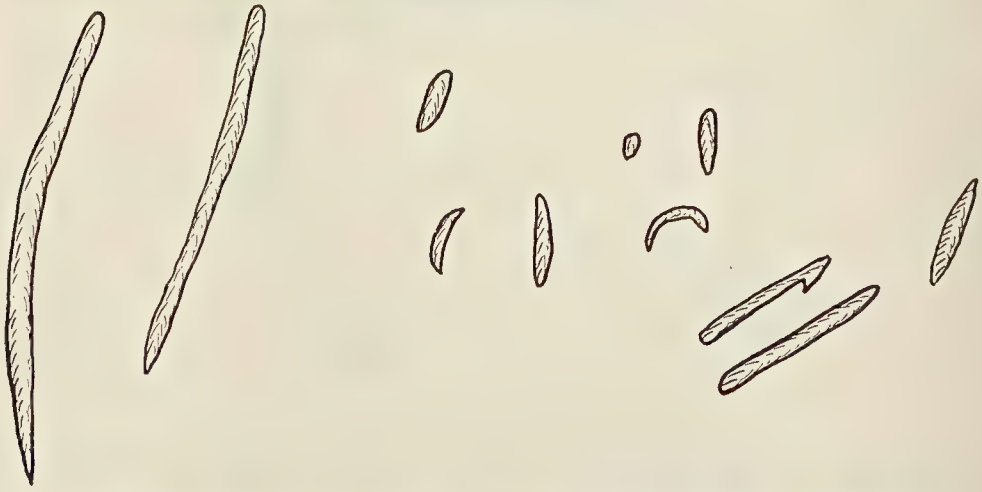


FIG. 3.—The figures on the right, resembling kangaroo tracks, are eight and six inches respectively, while those on the left with the appearance of waddies are twenty and twenty-six inches.

In a hollow on the same rock is a somewhat complicated pattern bearing strong resemblance to a blue-tongued lizard. It is twenty inches in length with four very life-like legs. Two other figures twenty and twenty-six inches in length and approximately two inches across, lying side by side, appear to be waddies as used by the natives. In all there are more than two hundred separate figures.

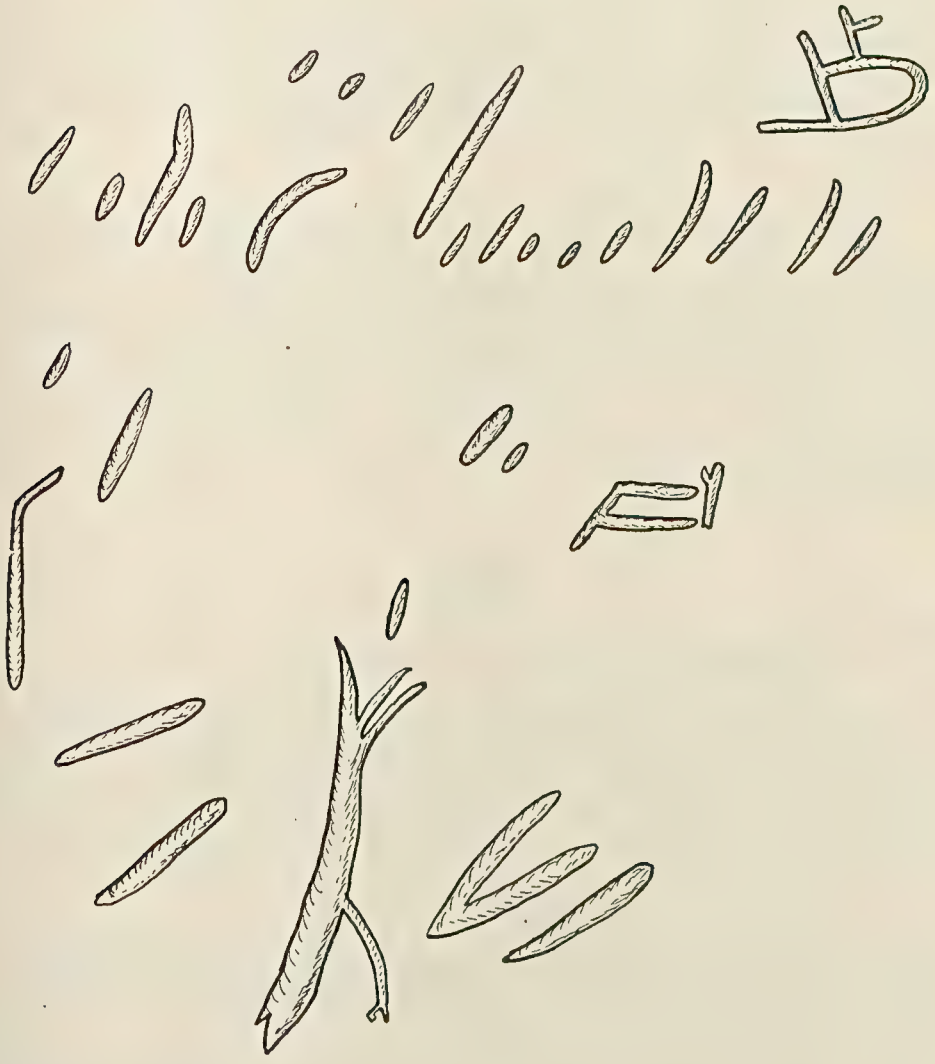


FIG. 5.—The large figure at the bottom, resembling a kangaroo, is two feet in length. The other patterns are correspondingly smaller. Note the similarity to young moons.

Mr. A. L. Meston, accompanied by Miss R. McCullock, visited these workings with me in 1950. He said that they were a new group and not the ones he had found. A few weeks later I found those he had previously mentioned. Like the set just described they are on the south-western slope of the dolerite ridge of " Billy Blue ". From a saddle in the hill, which is sprinkled with shell remains, a creek bed, usually dry, slopes down to a cove called " Creasey's Mistake ". About three hundred yards from the sea on the western side of the depression of the creek is a sandstone outcrop sloping at an angle of twenty to forty degrees from the horizontal and facing the south-east. The lower edge of the rock ends abruptly in a sheer drop of twenty feet into dense dogwoods which are the chief vegetation of the gully. The topmost edge shelves off to a dense tangle of comasperma and bracken up to six feet in height. A permanent water soakage is to be found in the creek bed fifteen yards below.

The workings themselves were partly covered by earth which had moved down from the hillside. This I removed and uncovered three separate groups which were connected with scattered figures. As with the group already described, the method of production is debatable but apparently the depressions were made by friction with a hard stone implement. There are no signs of chipping or gouging of holes and joining them as with those on the West Coast. A close search revealed no tool which could be used to perform the work. This appears to have been characteristic of all rock carvings on the mainland of Australia. They bear a strong resemblance to workings in South Australia both in form and subject.

6 7

FIG. 6.—In the major figure the left arm to the fork is eighteen inches, the one on the right twelve and the thick trunk eight inches.
FIG. 7.—The two longest arms measure twelve inches.

The depth of depression varies from one quarter up to two inches. Some figures approach the edge of the declivity so closely as to cause wonder at the skill of the aboriginal in maintaining a secure foothold. It is certainly not safe in ordinary footwear.

One area of surface approximately nine feet square is covered with innumerable patterns closely spaced and frequently crossing each other. As in the first group the designs resemble bird and animal tracks. Some are merely groups of straight lines of varying lengths. Others are reptilian in character. The rock surface is gradually weathering away. There are no visible signs of shell or animal remains in the vicinity, though both must have been abundant.

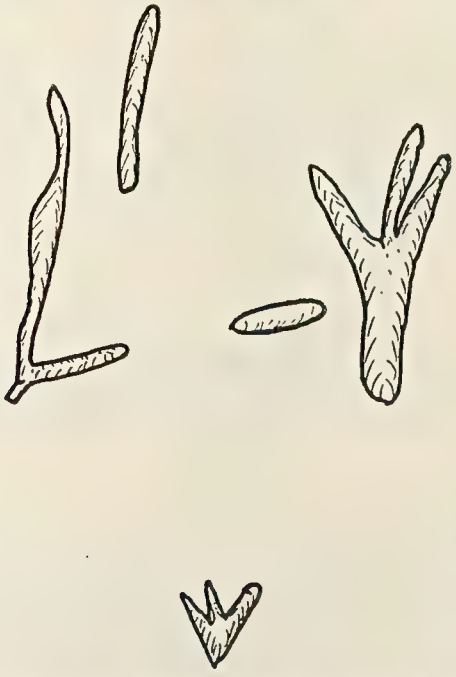


FIG. 8.—The figure to the right, like a birds foot, is eight inches long.

BOND BAY

These I found on a visit to the Port Davey area in 1950. They are situated on the north-western side of Bond Bay near the entrance to Kelly's Basin. The surface bearing the workings is an almost vertical wall of schistose slate which would form a comparatively easy medium to work. It is approximately fifteen feet high and leans outwards at an angle of about ten degrees. High water reaches to within thirty feet of the wall which is partially obscured by very tall bracken.

At the base of the cliff is a mound of shell-fish remains, of which the larger proportion are mutton fish. Implements collected were manufactured from quartzite and were crude in form. However, this hard material would be suitable for punching or gouging holes in such a soft surface. The site is protected from the coldest winds. As some of the patterns are eight feet from the ground, the native must have used some type of platform.

For the most part the carvings are a series of indentations from three to eight feet from the ground. At the top is a double row of punctures,

one directly below the other and approximately two inches in diameter. Eight pairs of holes are clearly visible but there were originally probably considerably more as the rock face to the left has begun to fall away on to the shell heap below.

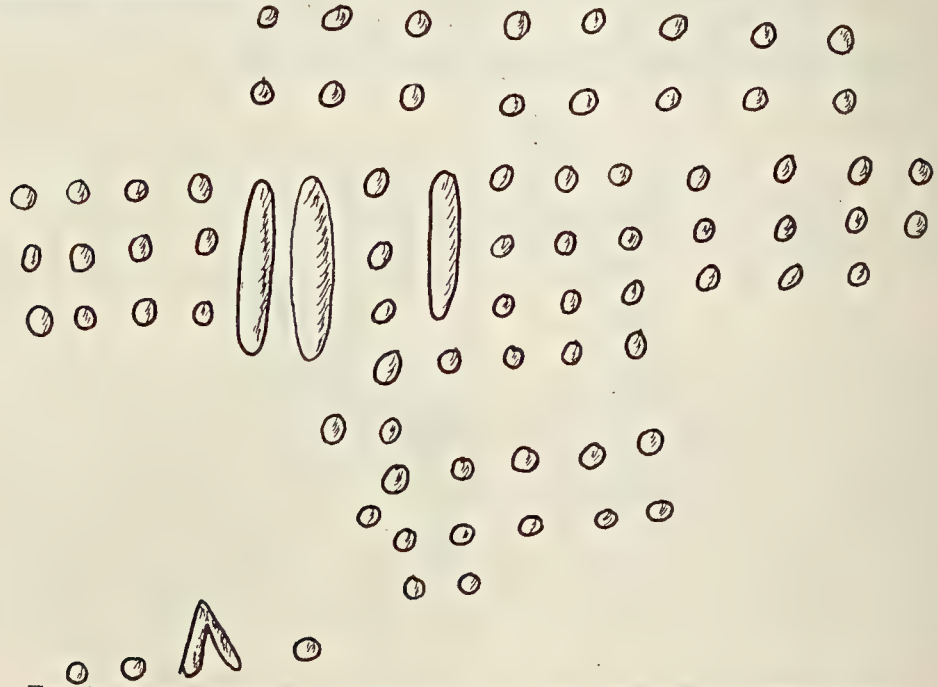


FIG. 9.—Rock engravings at Bond Bay near the entrance to Kelly's Basin. Note the indentations joined by bars.

The second series consists of three lines of holes one below the other with fifteen in each row and the eighth from the right is joined by a vertical bar. The same applies to the tenth and eleventh where the bars are more clearly defined. These bars are roughly seven inches in length. Below this group are rows of five and six holes respectively with three inches between each row. At the fifth from the right triple holes replace the usual pair. The series of indentations continues down the cliff face to within three feet of ground level.

The methods used by the Port Davey Tribe was evidently similar to those used by other West Coast Tribes further north. Possibly they had not reached the same stage of completion as those just mentioned.

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Geological Map of the North-Western End of Tasman Peninsula—A Revision

By

K. G. Brill
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and

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WITH 2 TEXT FIGURES

Abstract

The sedimentary rocks of the area are mainly Triassic sandstones with some Permian rocks near Turners Point and on the North-West of Slopen Island. Dolerite intrusions, Tertiary volcanic centres and basalt flows are also present. There are no Permian strata at Lime Bay as shown in previous maps.

Introduction

This study results from research on Permian strata in Eastern Tasmania. Reid (1922) who mapped the north-west end of Tasman Peninsula referred to calcareous mudstone of Permian age in the vicinity of Lime Bay. On examination, the rocks mapped as Permian proved to be Triassic sandstone. This anomaly led to the critical examination of the entire tip of the peninsula and the neighbouring Slopen Island, and to the preparation of a revised geological map. (Fig. 1.)

The area mapped consists of about 25 square miles. Good outcrops occur along the sea cliffs but few rocks are to be found inland. The area is underlain chiefly by Triassic sedimentary rocks which are intruded by Jurassic dolerite and Tertiary basalt.

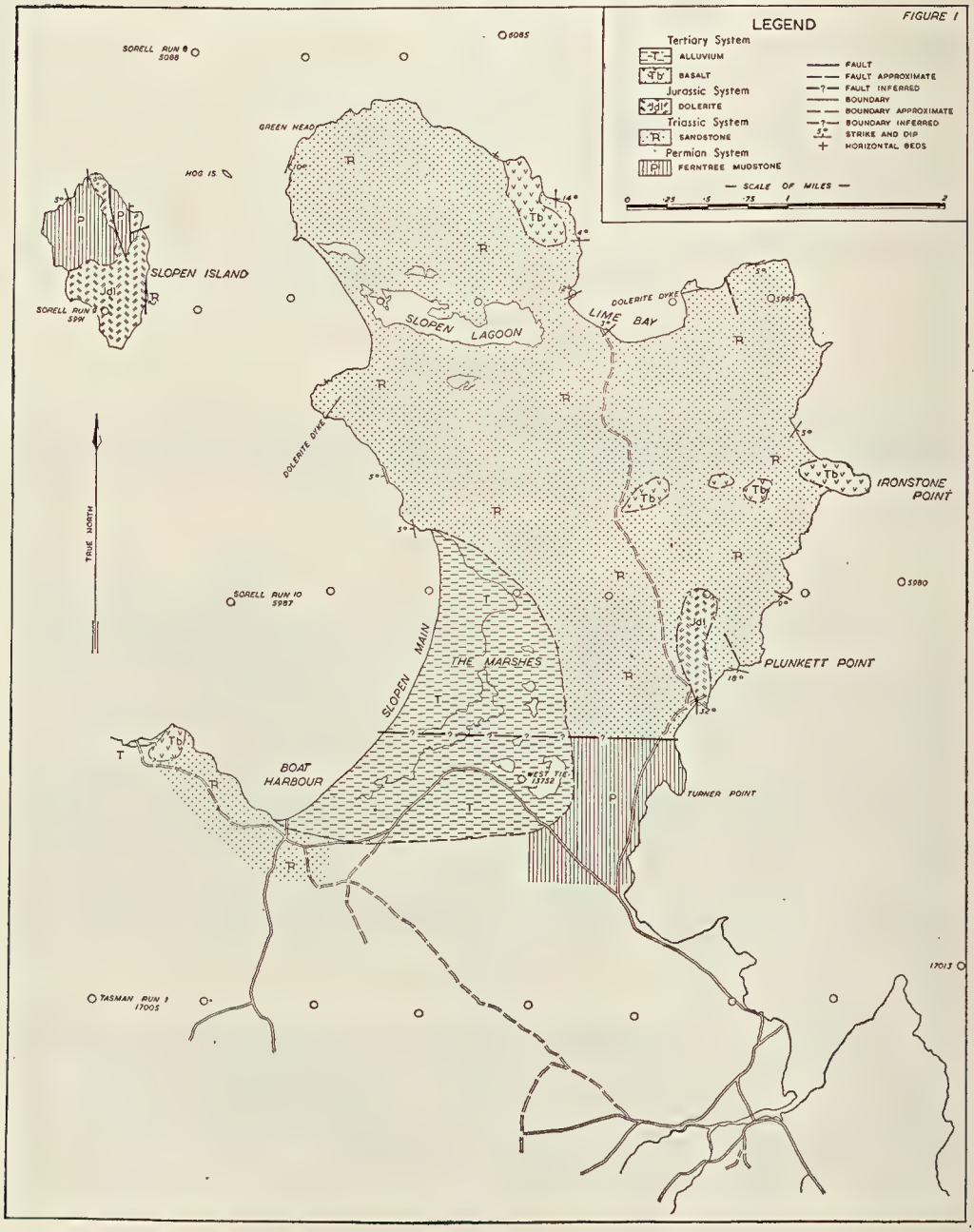
The writers wish to acknowledge the help and interest of Mr. Ian Jennings who called attention to the area and accompanied the writers on their initial visit.

Stratigraphy

Permian System

Mudstones of the Ferntree Formation outcrop in a small area along the western shore of Norfolk Bay at, and south of Turners Point. The stratigraphic contact with the Triassic is not exposed in the area. The formation is faulted against the Triassic sandstones on the north side of the outcrop. External moulds of spiriferoid brachiopods occur in the mudstone north of the abandoned jetty.

REVISED MAP OF LIME BAY AREA



Much of the western half of Slopen Island is underlain by Ferntree Mudstone which rests on a dolerite sill. The mudstone is about 170 feet thick and contains scattered small pebbles and a few spiriferoid brachiopods.

Reid described and mapped a large area of Permian strata surrounding the shore of Lime Bay, but no Permian rocks outcrop in the vicinity.

Triassic System

The most widespread strata in the area are Triassic in age. Gentle folds expose various beds in the sea cliffs, but faulting and lateral changes in lithology make it difficult to trace individual layers. The folds are due, in part, to the faulting and, on a smaller scale, to the erosion of slump bedding and other sedimentary structures which here, as elsewhere, are a feature of the Triassic rocks. The limbs of the synclinal folds dip at less than 5°.

No detailed section was measured here but the general sequence from top to bottom is:

9. Sandstone, yellow, feldspathic.
8. Siltstone and shaly siltstones, grey and yellow with carbonaceous matter and coal.
7. Sandstone, yellow, massive, crossbedded.
6. Sandstone, yellow, spotted, with small limonitic concretions.
5. Shale, dark-red, silty, with sandstone and siltstone, grey and yellow.
4. Sandstone, yellow, spotted, with limonitic concretions.
3. Sandstone, yellow, massive.
2. Shale, grey.
1. Sandstone and siltstone, yellowish-green, with large limonitic cannonball concretions.

The total thickness may be 100 feet or more. The cannonball concretions of Unit 1 have been reported from Police Point (Hale, 1953) and the dark-red shale of Unit 5 has been observed in many parts of Tasmania. Both may become useful marker beds in the future but the sequence in this area has not been correlated with other Triassic sequences except in a very general fashion.

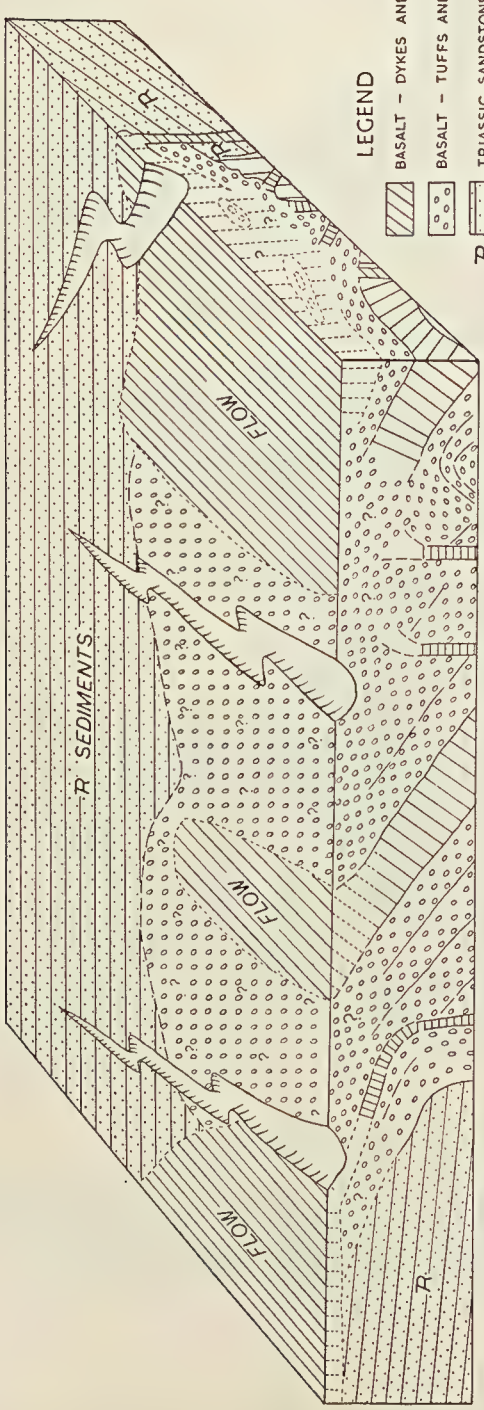
The coal deposits of the area were discussed by Reid (1922). Judging from the piles of waste on the surface the workings were rather extensive, but the entries and shafts have collapsed.

Clay for brickmaking was obtained by convict labour from a pit north of the convict barracks, from Unit 8 of the section listed above. Building stone was obtained from a quarry in massive yellow sandstone near Plunkett Point.

Igneous Rocks

Dolerite

Dolerite intrudes the Triassic strata in many localities: at the coal mines, at North-West Head, north of Slopen Main, at the east end of Lime Bay, on Hog Island, and Slopen Island.



BLOCK DIAGRAM SHOWING GREEN HEAD VOLCANIC STRUCTURE, TASMANS PENINSULA

FIGURE 2

At the coal mines, the boundaries and structural relations of the dolerite are not clearly defined. The intrusion seems to be a dyke which becomes a sill dipping gently to the north-east. All of the shafts seem to have penetrated dolerite and at the collar of the main shaft about 15 feet of dolerite is exposed. On North-West Head, the dolerite is strongly shattered and the outcrop continues southward for several miles broken only by small inclusions of Triassic strata. In the sea cliff north of Slopen Main, a well-developed dyke about 15 feet wide strikes 19° and can be traced inland for several hundred yards. Another small dyke strikes 54° across the small headland at the east side of Lime Bay. Hog Island which lies between Green Head and Slopen Island consists entirely of dolerite and the eastern half of Slopen Island is underlain chiefly by dolerite. The shore on the north side of Green Head and on the south side of the Boat Harbour strewn with dolerite boulders. Inasmuch as there is no dolerite on the land at these localities, it is assumed that the adjacent sea floor consists of dolerite.

Basalt

Basaltic dykes, lava flows, and agglomerate beds of Cainozoic age occur at several localities.

Ironstone Point consists of basalt which appears to have been intruded as a dyke into Triassic strata, perhaps along a fault. Three hills west of Ironstone Point are capped by basalt and dyke-like masses appear to have been feeders for the capping material. Some agglomerate and volcanic bombs occur locally.

A small pipe-like mass of vesicular basalt completely surrounded by Triassic sandstone may be observed on the wave cut bench between Plunkett Point and Ironstone Point.

A fine example of a small volcanic centre occurs in the sea cliff about 0·5 miles west of Lime Bay. It is a composite structure of interbedded basalt flows and beds of agglomerate (Fig. 2). The writers refer to this structure as the Green Head Volcano. The lowest agglomerate bed which lies at sea-level at the eastern end of the structure consists of basaltic tuff with large fragments of Triassic sandstone and dolerite. Numerous volcanic bombs ranging in length from three inches to three feet are associated with the agglomerate beds. Five or six steeply-dipping dykes radiate from the seaward side of the outcrop.

Another ancient volcanic vent lies on the peninsula at the west end of the Boat Harbour. It is not as well exposed as the vent on Green Head, but contains agglomerate as well as basalt flows. Several basalt dykes radiate from the seaward side.

Cainozoic Sediments

Beach gravels in the bay north of North-West Head consist of dolerite cobbles and pebbles loosely cemented with iron oxide. They seem to lie against the basaltic volcanic rocks. The age of the gravels has not been determined; but the fact that they are partly consolidated suggests that they may be of late Cainozoic age.

Much of the area is covered with loose sand and sandy soil, which appears to have resulted from the breakdown of Triassic sandstones. Source-bordering sand dunes of notable size occur at Slopen Main and at the south-west end of Slopen Lagoon.

The topography is in extreme youth and it is likely that much of the low-lying land area is newly upraised above sea level. Many undrained depressions are present and the stream drainage has scarcely accommodated itself to the topography. For example, on the north coast an intermittent stream runs into the sea at the end of a peninsula, but no streams are present in the bays on either side of the peninsula.

Structure

The structure of the area is simple. The Triassic strata are gently folded and are broken by numerous high-angle faults of small throw. The majority of the faults tend to strike about 20°. A smaller number tend to strike about 300°. The former set may be associated with the intrusion of dolerite dykes.

In addition, a primary set of joints seems to trend about 150° and the secondary set about 260°.

Bibliography

Hale, G. E., 1953.—The Geology of the Dover District. *Pap. & Proc. Roy. Soc. Tas.* Vol. 87, 1953.

Reid, A. M., 1922.—" The Coal Resources of Tasmania ". Tas. Dept. Mines, Min. Res. No. 7, pp. 118-122.

Papers and Proceedings of the Royal Society of Tasmania, Volume 88

A Sterile Eucalypt

H. N. Barber
University of Tasmania

(WITH 1 PLATE)

Summary

A single tree of an unnamed species of Eucalyptus showed a genetic abnormality which prevents abscission of the operculum from the buds. The tree is seed sterile but the buds may persist on the tree for four years.

Two populations of a Eucalyptus species are known from the east of Tasmania. The trees are closely related morphologically to *E. ovata* and *aggregata*. The umbels are seven-flowered and the adult leaves symmetrical and broad like those of *E. ovata*. The juvenile foliage resembles that of *E. aggregata* in the elliptical shape. The leaves are, however, much larger (up to 2″ long). The fruit and bud shapes are different from those of *E. ovata* and *aggregata*. Instead of the conical shape so characteristic of these two species, the buds are more cylindrical and the fruit truncate-ovoid or ellipsoid (see plate). Pending further study of the natural populations, the exact taxonomic status of the form must remain in doubt. They occur on the granite hills behind Bicheno and about 4 miles north of Cranbrook on the road to Bicheno. The two known populations are thus about 15 miles apart. The trees are stunted mallees rarely reaching 15 feet high.

Among the Bicheno population one sterile tree was observed in February 1952. At first sight it appeared to be covered with "fruit" of a peculiar shape. There were four age classes of these structures. On the ordinary trees nearby there were three age classes of fruit and one of buds. (see plate). The fruits on these trees dehisced normally a few days after collection. Those on the sterile tree do not dehisce.

Dissection of the abnormal "fruits" showed that they were overgrown buds, complete with operculum which never falls off. In the three older age classes, the operculum covered shrivelled and dead stamens, which were still arranged in the way characteristic of buds with the anthers bent inwards and downwards towards the base of the style. The style although dead appeared normal in structure, projecting straight up from its attachment to the ovary so that the stigma was placed in its normal position close beneath the apex of the operculum. The anthers contained dead pollen grains which, however, had a normally developed shape and wall structure. No signs of their having germinated were observed, although germination has sometimes been observed of pollen grains in the anthers of *E. risdoni* and *salicifolia*, when mature buds are kept in stoppered glass tubes. Buds of the youngest age class agreed in all visible particulars with those on normal trees.

The ovary of the overgrown buds was not as large as that of mature fruits; but it was considerably larger, as was the operculum than that of mature buds. Some growth of the unopened buds must therefore take place in the period after they would normally have opened. This growth is not caused by self-pollination in the unopened buds. No fertile seed could be found in buds of any of the four age classes. The carpels of the three older age classes contained the shrivelled remnants of ovules, resembling the sterile "chaff" which always accompanies fertile seed in the Tasmania species of the Macrantherae.

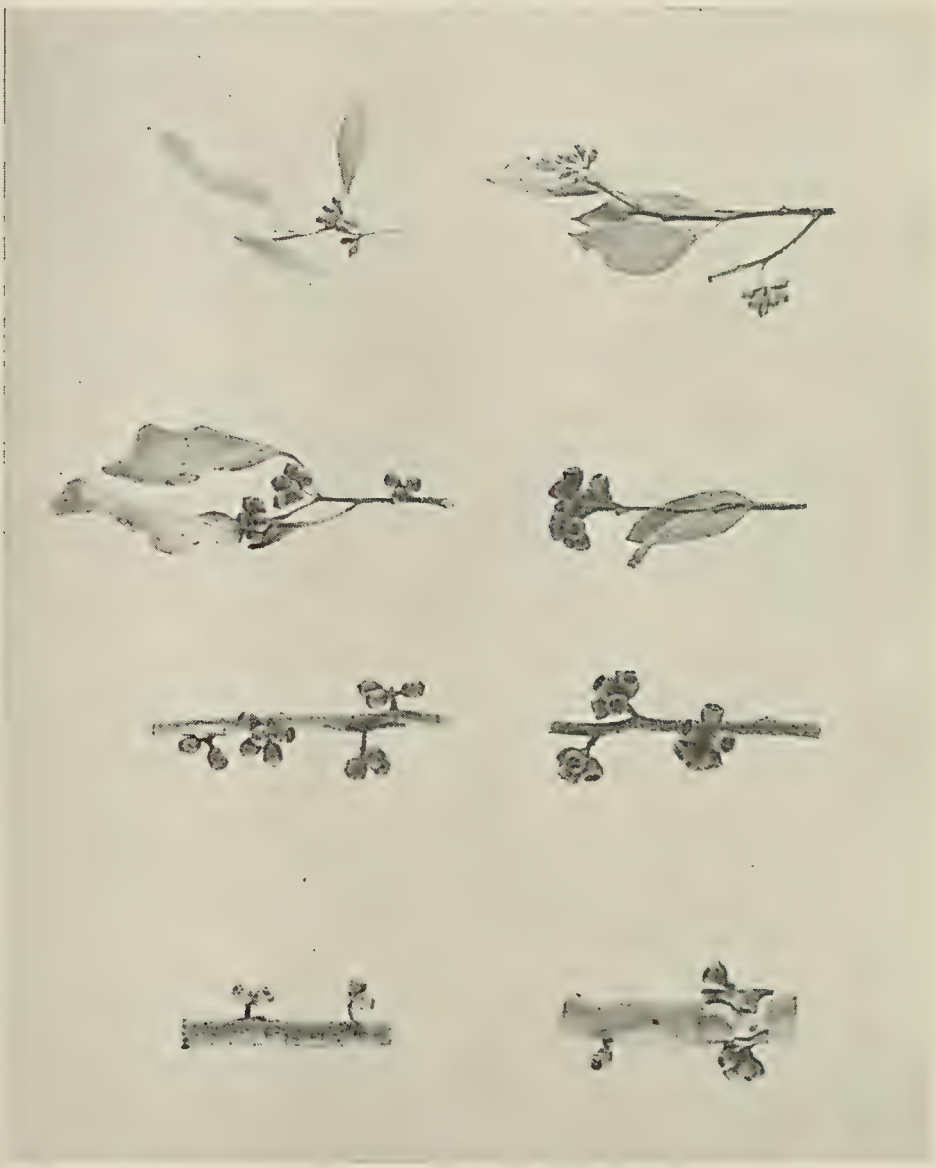
In longitudinal sections (kindly cut by R. H. Cruickshank) of the buds of all age classes, no trace of the abscission layer between operculum and ovary could be seen. In normal buds the abscission layer is difficult to see until just before the buds open when it is visible as a line of weakness, the cells tending to separate during cutting at this level.

The sterility of this tree, thus, appears to be caused by some derangement in the normal mechanism for abscission of the operculum. Mr. W. D. Jackson has noticed a sporadic failure of the operculum to absciss in several alpine species, e.g., *E. urnigera* and *subcrenulata*. An occasional bud in these species may retain its operculum attached either completely or, more usually, only over a part of its circumference. This persistence may be caused by frost or insect damage to the abscission layer. In the Bicheno tree, the derangement is complete. The tree had several stems each loaded with thousands of unopened buds. No normal fruits were present. Injury by insect attack was no greater than on normal trees. The developmental abnormality is, thus, due to genetic causes. Possibly, it might be caused by a single recessive gene.

It appears that the unopened buds can remain attached to the tree even for as long as four years. It is probable that bud formation in this tree and in this population is annual as in most eucalypts. If this is the case the four age classes would represent four successive crops of buds, the youngest of which would presumably be ready to open, if the genotype allowed it, in a few months time. The oldest crop of unopened buds (like the oldest crop of fruits on normal trees) would be between three and four years old. It is surprising that unpollinated buds should remain so long on a tree. In eucalypts with normally opening flowers, unpollinated flowers rarely persist longer than a month after the operculum falls. An abscission layer develops at the base of the pedicel of unpollinated flowers. It may be that, in the sterile tree, the gene causing failure of abscission of the operculum has a correlated (pleiotropic) effect on the formation of the abscission layer in the pedicel. However, abscission of the leaves, when they are about two years old, follows the normal course.

Some of the earlier workers with *Eucalyptus*, e.g., Muller, suggested, on the bases of the peculiar morphology of the operculum that eucalypt flowers were adapted for self-pollination even before the flowers opened. The existence of this tree and many other facts of floral biology, e.g., the pronounced protandry in many species, show that this view is incorrect.

The nomenclature used in this paper is that of Brett (these proceedings for 1937, p. 75), for reasons given in detail in my notes of 1952 and 1953 (Australian Journal of Science *14*, p. 148 and *16*, p. 9).



Bottom row from right to left, half-grown buds, one year, two year and three year old fruits of Bicheno eucalypt—normal tree.

Top row, half-grown buds, one year, two year and three year old buds from sterile Bicheno eucalypt.

PAPERS AND PROCEEDINGS

OF

The Royal Society of Tasmania

Volume 89

Edited by William Bryden

PUBLISHED BY THE SOCIETY

The Tasmanian Museum and Art Gallery, Hobart

1955

Royal Society of Tasmania

Volume 89

Annual Report

AND

Proceedings

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The Royal Society of Tasmania

Volume 89

Patron:
Her Majesty the Queen.

President:
The Rt. Hon. Sir Ronald Cross, K.C.M.G., K.C.V.O.

Vice-Presidents:
S. Angel (till April, 1955).
T. Hytten, C.M.G., M.A., from May, 1954, 1956 (till April).

Council:
S. W. Carey, D.Sc., 1954, 1955, 1956.
L. W. Miller, M.Agric.Sc., F.R.E.S., 1954, 1955, 1956.
J. W. C. Wyett, B.Sc., A.A.C.I., 1954, 1955.
F. C. Wolfhagen, LL.B., 1954, 1955.
H. N. Barber, M.A., Ph.D., 1954.
I. G. Anderson, F.R.S.A. (Lond.), 1954.

Hon. Secretary and Librarian:
W. Bryden, M.Sc., Ph.D., F.R.S. (Edin.).

Hon. Treasurer:
G. E. A. Hale, B.Sc.

Hon. Auditor:
A. M. Hewer.

Hon. Editor of the Papers and Proceedings:
W. Bryden.

Standing Committee:
J. W. C. Wyett, L. W. Miller, S. W. Carey, W. Bryden.

The Royal Society of Tasmania

Annual Report, 1954

The Annual Meeting was held on the Society's Room, Tasmanian Museum, on 2nd March, 1954.

Mr. L. W. Miller, Vice-President, presided.

The following Office-bearers were elected:—

Vice-President: Under the Society's Rules Mr. L. W. Miller retired from the office of Vice-President, and Professor T. Hytten was appointed in his place (retiring 1956).

Hon. Secretary and Librarian: Dr. W. Bryden.

Hon. Treasurer: Mr. G. E. Hale.

Hon. Auditor: Mr. A. M. Hewer.

Council: Under Rule 21 Professor S. W. Carey and Mr. C Bisdee retired as members of the Council but were eligible for re-election having served only two years After a ballot had been taken Professor Carey and Mr. L. W. Miller were elected for a period of three years.

The names of the full Council for 1954 are given on the previous page.

The Council made the following appointments at its first meeting:—

Standing Committee: Mr. J. W. C. Wyett, Mr. L. W. Miller, Professor S. W. Carey and the Hon. Secretary.

Board of Trustees of the Tasmanian Museum and Board of Trustees of the Botanical Gardens:

Board of Trustees of Tasmanian Museum: Professor T. Hytten and Professor A. Burn.

Board of Trustees, Botanical Gardens: Mr. S. Angel.

Representative to Library Association: Dr. W. Bryden.

Meetings: Nine ordinary meetings were held during the year. A Conversazione was held at the close of the meeting on 2nd November when supper was served in the Art Gallery to approximately 200 people.

Library: During the year 271 volumes were added to the Library in addition to a number of reports and pamphlets from British and Foreign Institutions and learned societies. The number of institutions on the exchange list is now 303. The Library now consists of 30,070 volumes.

Sir Ernest Clark—Gift: Books and papers—127 items in all—from the library of the late Sir Ernest Clark, were received during the year and added to the library lists. The Council expresses its sincere thanks to Lady Clark for her assistance in this matter and for her continued interest in this Royal Society.

Changes in Staff: Miss D. Bulman resigned her position as Assistant Librarian and Miss E. M. Geddes was appointed in her place from 23rd August. Miss Alicia Miller, who had been on the Library staff was transferred to the Museum.

Membership: The Society consists of the following members:—

Honorary Members		2
Corresponding Members		1
Ordinary Members:		
Class A	264	
Class B	162	
	—	436
Life Members		31
Associate Members		16
TOTAL		486

During the year 21 names were removed from the list of Members owing to deaths, resignations, &c., and 36 new members were elected.

Deaths: The Council regrets having to record the deaths of the following members:—Mrs. A. H. Clarke, Mr. J. Connor, Dr. D. H. E. Lines, Miss C. Travers, Professor F. Wood-Jones (Honorary Member).

W. H. Hudspeth Memorial: The Hudspeth Memorial Volume referred to in the last report was printed and is now on sale. Subscribers to the fund may receive a copy at a special rate—other members may obtain copies from the Tasmanian Museum Office.

Papers and Proceedings: The Council is grateful to the Tasmanian Government for the amount of £550 provided as portion of cost of printing the Papers and Proceedings of the Royal Society.

The Council also would like to record its thanks for the help given by the University of Tasmania in providing a sum of money enabling the Society to publish certain works by members of the University Staff in the Papers and Proceedings.

Rising costs have made it necessary for the Council to reconsider the whole question of printing the Papers. It is hoped that effective steps may be taken in the next twelve months to enable the Society to continue printing the Papers and Proceedings each year.

Northern Branch

Annual Report, 1954

At the Annual General Meeting of the Royal Society of Tasmania (Northern Branch), held at the Queen Victoria Museum Lecture Room on Friday, April 23rd, 1954, the following office-bearers were elected under the rules of the Society:—

Chairman: Mr. Roy Smith.
Vice-Chairman: Mr. K. R. von Stieglitz.
Council Members: Mr. G. H. Crawford, Mr. E. Padman, Mr. B. H. Travers.
Hon. Secretary and Treasurer: Mr. W. F. Ellis.
Members of Council retaining their offices for another year: Mr. G. Willing, Mr. J. Rex.

Meetings.—During the year eight General Meetings were held, at which the following papers were read:—

May 28th—The Development of Tasmanian Railways, by Mr. W. A. Townsley, M.A.
June 25th—Little Known Parts of Tasmania, by Mr. N. H. Harvey.
July 23rd—James Meehan, Architect and Surveyor, by Mr. B. H. Travers, O.B.E., M.A., B.Litt.
August 20th—Early Tamar Portraits, by Rev. E. C. Rowland, F.R.Hist.S., F.R.G.S.
September 10th—Medical Practice and Personalities in Hobart Town, 1828-1837, by Dr. W. E. L. H. Crowther, D.S.O., M.B., F.R.A.C.P.
September 24th—The Zonation of Animals, by Dr. E. R. Guiler, B.Sc., Ph.D.
October 27th—John Pascoe Fawkner in Tasmania, by Mr. Robert Sharman, B.A.
November 26th—Jorgan Jorganson in Tasmania, by Mr. P. R. Stephensen.

Excursions: The Northern Branch conducted excursions to the following places of historic interest:—

May 23rd—Bishopsbourne, led by Mr. K. R. von Stieglitz.
September 12th—Perth and Haggerstone, led by Mr. H. Stancombe.
October 24th—Corra Lynn Estate, led by Mr. K. R. von Stieglitz.
December 5th—Hagley House and Westfield, led by Mr. Roy Smith.

Membership: The present membership stands at:—

14 life members
140 ordinary members
12 associate members

The Society records with regret the death of Mr. C. G. Ryan, a greatly respected member.

Library: Eight books were added to the library.

Sesquicentenary Celebrations: During 1954, the Northern Branch contributed considerably toward activities celebrating the sesquicentenary of British settlement in Northern Tasmania.

As its own contribution, T. J. Lempriere's manuscript "Penal Settlements of Van Diemen's Land", was edited and published in an edition of 750 copies. Permission to do this was granted by the Trustees and Librarian of the Mitchell Library, Sydney, whose aid is gratefully acknowledged. This publication has been very well received and to date over four hundred copies have been sold or are in circulation.

Plans for a memorial to be erected near the site of the first permanent settlement at Yorktown, West Tamar, were kindly prepared by Mr. G. Willing, and, in conjunction with the Beaconsfield Municipal Council, a grant was obtained for its construction from the Sesquicentenary Committee. The construction of this memorial and its maintenance was then undertaken by the Beaconsfield Council. This memorial, which has aroused favourable comment, was unveiled by His Excellency, Rt. Hon. Sir Ronald Cross, Bart., K.C.V.O., K.C.M.G., on November 14th, 1954.

The Northern Branch took part in the unveiling of a plaque erected at Rosevears, West Tamar, to commemorate the launching of the "Rebecca" by Captain George Plummer in November, 1834.

Representatives of the Society also approached the Sesquicentenary Committee and the Launceston City Council, suggesting that a similar memorial be erected in King's Park to commemorate the landing at the site of Launceston by Lieut. William Collins. This project was carried on independently by the Launceston Corporation and was unveiled on November 13th, 1954. As the inscription finally chosen is misleading, the Society has made a recommendation to the Council that it be amended as soon as possible.

Royal Society of Tasmania
(Northern Branch)

Statement of Assets and Expenditure for Year Ended December 31st, 1954

RECEIPTS.	£	s.	d.
Balance at 1.1.54	66	15	0
Subscriptions	111	19	2
Bank interest	3	4	5
Donations	10	0	0
Sales, publications	48	6	7
	£240	5	2

EXPENDITURE.	£	s.	d.
Lectures	10	6	9
Library	14	10	5
Printing and advertising	108	18	0
Postage and petty cash	34	9	3
Stationery	2	3	0
Balance carried forward	69	17	9
	£240	5	2

Examined and found correct.

J. R. FORWARD, Auditor.
25.2.55.

F. ELLIS, Hon. Sec./Treasurer.

Abstracts of Proceedings

2nd March, 1954

Annual Meeting

The Annual Meeting was held in the Society's Room, Tasmanian Museum. Vice-President, Mr. L. W. Miller, presided.

The following Office-bearers were elected for 1954:—Professor T. Hytten was elected Vice-President in the place of Mr. L. W. Miller, who retired under Rule 12; Honorary Secretary, Dr. W. Bryden; Honorary Treasurer, Mr. G. E. Hale; Honorary Auditor, Mr. A. M. Hewer.

Under Rule 21, Professor S. W. Carey and Mr. C. Bisdee retired as members of the Council but were eligible for re-election, having served two years only. Four nominations were received for these two vacancies and after a ballot had been taken, Professor S. W. Carey and Mr. L. W. Miller were elected for three years.

Professor Carey delivered an illustrated lecture entitled "Progress in the Controversy on the Evolution of Continents".

6th April, 1954

A meeting was held in the Society's Room. Professor S. W. Carey, a Member of the Council, presided.

The following were elected members of the Society:—Mr. L. S. Bethell, Mrs. J. Bowkett, Mr. K. G. Brooks, Mr. W. F. Ellis, Dr. J. C. H. Morris, Mr. E. D. Rowland, Mr. J. R. Skemp.

Mr. J. B. Thwaites delivered an illustrated lecture entitled "In the Footsteps of Sir John Franklin overland from Lake St. Clair to the Gordon River", of which the following is an abstract:—

> An account of an expedition organized by the Hobart Walking Club as a contribution to Tasmania's Sesqui-centenary celebrations.
>
> The six members who made this trip through Transylvania, as the area was designated on early maps of Van Diemen's Land, followed the historic route of 1842, using for guidance the diary of David Burn, one of Franklin's party.
>
> In appearance the country traversed was found to be largely as described by Burn. The great rain forests flanking the Franklin and Gordon Rivers had not been damaged by bush fires. However, the heavy fires of the late 1930's had encroached only upon the fringes of the Lachlan Plains and Calder Pass, also swept the steep slopes of the Acheron Valley.
>
> In the 112 years since Franklin's journey tracks were cut by Government parties to expedite exploration. In 1863 Charles Gould cut a track from the Gordon River towards Frenchman's Cap and reported on finding traces of Franklin's track. James Calder had spent 32 weeks on this work. Thirkell opened the track out again in 1906 but again it quickly reverted to nature from lack of use.

The discovery of payable gold on the Jane River in 1934, led to a mild rush and during its brief life the diggers used Calder Pass to reach the field.

The departure of Sir John's party had been unavoidably delayed until late in March, by difficulties which finally culminated in his dismissal of John Montagu, the Colonial Secretary.

The party comprised Sir John and Lady Franklin, Joseph Milligan, surgeon and botanist, James Calder, later to become Surveyor-General, who had cut his track from the Gordon in readiness, David Burn, a colonist, Bagot, aide de campe, O'Boyle, Franklin's orderly and Stewart, Lady Franklin's maid. Of the 16 convicts who accompanied the party, 12 were carriers loaded with 66 lb. kangaroo hide knapsacks and four volunteer bearers for Lady Franklin's chair, two to carry and two to relieve every half hour. This chair, made at Port Arthur was borne on stout poles. It is now in the Tasmanian Museum.

Sir John's cavalcade left Hobart on 24th March and reached Lake St. Clair nine days later. Here Calder took over and all superfluous equipment was sent back. The party was on foot from this point onwards, including Lady Franklin, who readily gave her chair up to Stewart who fell ill a few days later.

Franklin's party named a number of features during their epic journey. Among those in use to-day are Mount King William beneath which they camped, Calder Pass and Lachlan Plains, after Lachlan Macquarie, Governor of New South Wales and Van Diemen's Land. Fatigue Hill was renamed Mt. Arrowsmith by Strzelecki. Sir John expected the journey from Lake St. Clair to the Gordon would take a week. However, bitter weather, with rain and snow day after day seriously delayed the party. Flooded creeks and rivers added to their difficulties. The first serious delay occurred on the Loddon Plains flanking the eastern foothills of Frenchman's Cap where the party was encamped for six days at " Detention Corner ". Calder and Burn went ahead with two convicts in an attempt to reach the Gordon River and hold the small schooner " Breeze " which had been sent round from Hobart Town to await the travellers.

The Franklin River, two days' journey ahead, had become a raging flood and barred their way. Here they were forced to wait a further eight days during which Sir John and the rest of the party came up. During this enforced wait two convicts attempted to cross on a raft and were swept a mile downstream where they made a landing on the far side. However, they managed to reach the ship which fortunately had waited beyond the agreed time.

The marooned party meanwhile built a double canoe from Huon Pine logs which they named " Eleanor Isabella ", after Sir John's daughter. The party subsequently crossed the Franklin in this craft and named their crossing " Eleanor Ferry ".

The Walking Club party discovered a large cave on the edge of the Lachlan Plains which tallies with Burns' description of " Christmas Rock " in which Calder and his convict track cutters had sheltered from a storm on Christmas Day, 1840. Burn was enraptured by the view of Frenchman's Cap from the cave mouth.

Franklin's party was on extremely slender rations at this stage of their journey. Their sole diet had been salt messpork, damper cooked in the frying pan and black tea sweetened with brown sugar. Sir John insisted that he and his party suffer a further cut in rations on an equal footing with the convict carriers.

When they finally emerged from the Franklin River gorge onto the High Plains on the western bank they experienced the first fine day since leaving Lake St. Clair 19 days before.

All were extremely thankful to descend from the plains to the waiting ship at Expectation Reach, 10 miles upstream from the mouth of the Gordon.

On the way down Macquarie Harbour Sir John considered it his duty to call in at the old convict station at Settlement Island to judge for himself as to whether the decision to close the station seven years before and transfer to Port Arthur had been a wise one.

Storms and contrary winds prevented the "Breeze" from leaving Macquarie Harbour for a further three weeks and the whole ship's muster, in desperate straits for food, were forced to spend the time fishing to augment the ship's meagre supply of provisions which had been almost exhausted by the delays and the extra mouths to feed.

Meanwhile the authorities in Hobart Town were greatly concerned at the lack of news of the Vice Regal party and the ship "Eliza", of 150 tons, was despatched to make a search. The "Vansittart" also left Port Dalrymple and the ship "Beagle" was diverted from her survey work to join in the search.

On the 15th May the "Breeze" finally cleared Macquarie Harbour and met the "Eliza" a day out, when the party quickly transferred to her. The "Breeze" was sent on to Hobart Town to carry news of the Party.

A land party of six convicts under James Bastian was also despatched and after an arduous journey reached the Gordon but the Franklins had left no word of their safe embarkation. Bastian continued his search along the southern shores of Macquarie Harbour and then followed down the coast almost to Port Davey. Owing to shortage of food and the arduous journey they were just able to get back to Macquarie Harbour where they built a raft and landed on Settlement Island. They were able to find a few small potatoes in the gardens of the abandoned settlement. This was their only food for the return to Lake St. Clair. They used the canoe "Eleanor Isabella" to get back across the Franklin but capsized when half way over and lost the few remaining potatoes. By this time they were so weak that they could proceed little further.

In the meantime another land party had been sent out and it found Bastian and his men in dire straits, starving and unable to walk as their boots had been completely worn out.

On board the "Eliza" the redoubtable Sir John Franklin had decided to put in to Port Davey, where he was joined by the "Beagle" and "Vansittart". He also decided to check the bearings of South West Cape, the accuracy of which had been in doubt. It pleased him to be able to affirm that his old shipmate Matthew Flinders' calculations had been correct.

When they finally reached Hobart Town a great concourse of colonists had assembled on the waterfront to welcome the return of the Lieutenant Governor and his party. Sir John held a levee in the afternoon.

Free pardons were granted to several of the convicts as a reward for their labours on the Franklin Expedition through Transylvania.

4th May, 1954

A meeting was held in the Society's Room. Professor T. Hytten, Vice-President, presided.

Mr. J. B. Thwaites was elected a member of the Society.

Mr. G. H. Newstead delivered an illustrated lecture entitled "The Scintillation of Radio Stars", of which the following is an abstract:—

The lecture dealt with the work on which the speaker had been engaged at the Cavendish Laboratory, University of Cambridge, whilst on study leave from the University of Tasmania.

The first part of the lecture dealt with the discovery and properties of the radio stars—points of space which emit radio waves. Radiation from space was discovered by Jansky in 1932 when investigating the residual "static" present in radio receivers in quiet localities. Jansky found that the location of the noise kept sidereal time and was thus not part of the solar system. It was pointed out that resolution limits the accuracy of position finding and that to get greater resolution larger aerials or higher frequencies are necessary. Not much progress was made until 1946 when Hey, Parsons and Phillips, using equipment developed during the war for radar, noticed fluctuations of intensity coming from the Cygnus region, which they correctly interpreted as a source localized in that region. This was definitely established in 1948 by Ryle and Smith (Cambridge) and Bolton and Stanley (Sydney) using radio analogues of the Michelson interferometer and Lloyd's mirror respectively. Ryle developed the phase switch interferometer for balancing out the background radiation, and some hundreds of radio stars have now been discovered. A brief survey of the characteristics and theories of the origin of the radiation was given.

The second part of the lecture dealt with the scintillation of the radio stars—this is the same as the twinkling in optical stars. The evidence for Hewish's theory that the fluctuations are caused by irregularities in the upper ionosphere was reviewed and showed to be consistent with all the evidence. The most striking thing about the fluctuations is the marked diurnal variation with a pronounced maximum at midnight. The author's work at Cambridge showed that the intensity of scintillation appears to follow a sunspot cycle.

Existing theories of the cause of the irregularities were then discussed. These theories are of two main types: the "particle" type in which the irregularities are produced by collision of particles with the upper atmosphere and those which propose a turbulence mechanism. It was shown that there were difficulties with both types of theories, but those in which particle ionization—possibly by solar material—appear the most promising.

1st June, 1954

A meeting was held in the Royal Society's Room. Mr. L. W. Miller, a member of the Council, presided.

The following were elected members of the Society:—Mr. G. M. Davies, Mr. N. Lochiel, Mr. G. T. Butler.

Dr. H. C. Reynolds delivered an illustrated lecture entitled "The American Opossum, the most primitive Marsupial", of which the following is an abstract:—

Dr. Reynolds outlined something of the life of the American Opossum, regarded as the oldest living mammal in America. He traced something of the history of knowledge of the animal, and the life history as well as of the habit and food of these animals.

In his researches special attention was paid to the reproductive phase of the animal especially at time of birth. Observations were made and definite data was obtained of the transference of the young to the pouch—this process is carried out by the young themselves without any assistance from the parent. Mortality is high at this stage and in observations made by Dr. Reynolds about 60 per cent of the young born to four females reached the pouch; those that failed to do so were lost.

The lecturer discussed the evolutionary place of the animal paying particular attention to the point that it has remained generalised so avoiding serious competition.

The lecture was illustrated.

6th July, 1954

A meeting was held in the Society's Room. Professor T. Hytten, Vice-President, presided.

The following members were elected:—Mr. K. Tyson, Mrs. G. T. Eddie, Miss J. Eddie, Mr. S. R. Bell, Archdeacon L. N. Sutton.

Mr. D. O'Driscoll delivered an illustrated lecture entitled "Gold Mining in Western Australia", of which the following is an abstract:—

Gold played an important part in the development of Western Australia, bringing an influx of capital and population to the State on several occasions when the economy was in difficulties. Tasmanians may feel some interest in the history of gold discovery in the West because there appear to be many links with the search for minerals in their own island. The discoveries in Tasmania were in general a little earlier than those in Western Australia, and there can be little doubt that spectacular successes achieved in the island provided some of the stimulus for the vigorous prospecting carried out by the pioneers in Western Australia. A Tasmanian would recognise the evidence for this in the many familiar names to be found among the titles of the mining leases. Even to-day many members of the mining community think of Tasmania as their home.

Of particular interest is the fact that the year 1954 marks the anniversary of the first official mineral survey in the goldfields country, and a splendid vindication of the judgment of an early explorer. In 1854 Surveyor Austin, commissioned by the Governor to look for signs of minerals in the inland country, came back to report that the area around Mt. Magnet gave every promise of possessing worthwhile gold deposits. This prediction roused little enthusiasm for more than twenty years until the first substantial discoveries were made. Now, a century later, Mt. Magnet is known for its celebrated Hill 50, one of the most notable mining successes of recent years.

The fame of the West Australian goldfields, however, rests mainly upon Kalgoorlie, where an area of ground about the size of an average wheat farm has produced more than one thousand tons of gold. Many fabulous tales are woven into its history but the boom days of the industry are gone and gold mining has settled down to become a steady engineering pursuit. As year by year the chances of finding new outcropping ore bodies diminish, the industry turns for the replenishment of its ore reserves to new and more scientific methods of search. Advances in the understanding of intricate fold patterns and structures have shed new light on the conditions which favour the formation of ore-bodies, and in recent years handsome rewards have come from persistent prospecting at depth along favourable structural features. A notable example of this type of prospecting is to be seen at Norseman, where a large quartz reef was considered to have been worked out in 1919 and lay idle for a number of years. A study of the anatomy of the vein in 1934 showed that the ore was related to certain structural features which could be expected to repeat again at greater depth. This caused the old mine to be re-opened and the discovery of new ore shoots which eventually reached prominence among the richest and most persistent gold producers in the State.

In the immediate post-war years an exhaustive study of the Bullfinch field caused Great Western N.L. to open up the old Copperhead mine and this property has now begun producing a large tonnage of gold ore. A large new town has come into being and an exploratory attack has been launched on a number of other prospects in the surrounding country.

By far the most interesting of all exploration projects, however, is that going on at the south end of the Kalgoorlie field. Here the possible prize is a repetition of the Golden Mile. The exploration now being carried out by Kalgoorlie Southern Gold Mines was preceded by five years of intensive geological mapping and interpretation. The concept which emerged led to the formation of the present company with its quarter-million pound capital to be devoted to drilling at depth down the pitch of the regional structure. Holes of five and six thousand feet depths are being undertaken, and about half the scheduled programme is complete. Results so far are considered to encourage further prospecting. As the attack continues the eyes of mining people in many parts of the world will watch with interest and expectation. Should success attend this venture it will mark an important milestone in the progress of scientific mineral prospecting.

4th August, 1954

A meeting was held in the Society's Room. Professor T. Hytten, Vice-President, presided.

The following were elected members of the Society:—Miss E. M. Gyenge, Dr. T. J. Ick.

Mr. P. G. Law delivered a lecture entitled "Experiences in the Antarctic", of which the following is an abstract:—

Mr. P. G. Law spoke of previous visits to Antarctic dealing more specifically with those explorers who used Hobart as a final base. The question of the type of research being carried out, relationship of the Antarctic base to Macquarie and Heard Island Stations were explained.

The whole question of organisation, the hazards to be faced in selecting a site and organising research parties were dealt with by the lecturer who also told the fascinating story of the reason why Mawson was chosen as the base station in the Antarctic. The organisation of the work this year and next year leading to the "International Year" in 1956 was discussed and the lecture was splendidly illustrated with numerous colour slides.

14th September, 1954

A meeting was held in the Society's Room. Professor T. Hytten, Vice-President, presided.

The following were elected members of the Society:—Mr. E. R. Henry, Mr. P. B. Rogers, Mrs. F. G. Henty.

Mr. Hal Missingham, Director of the National Art Gallery, of N.S.W., delivered an illustrated lecture entitled "Drawing: the classical misconception", of which the following is an abstract:—

Mr. Hal Missingham discussed the question of drawing as contrasted to watercolour and oil painting. Stress was laid on the various styles of drawing adopted by artists and many of these were well illustrated by well selected slides. The place of drawing as an art was emphasised by the lecturer.

5th October, 1954

A meeting was held in the Society's Room. Mr. I. G. Anderson, a member of the Council, presided.

The following were elected members of the Society:—Mrs. M. D. M. Fowler, Mrs. D. C. McLaren, Mr. J. R. Driscoll, Mr. G. H. Newstead, Mr. H. Shea, Mr. L. M. Shoobridge.

Brigadier A. D. Molloy delivered an illustrated lecture entitled "Some Impressions of the North American Continent".

2nd November, 1954

A meeting was held in the Society's Room. The President, His Excellency the Governor, Sir Ronald Cross, presided.

The following were elected members of the Society:—Mrs. I. F. Henry, Dr. M. B. Liederman, Mr. L. A. Moon.

The Chief Justice, The Hon. Sir John Morris, K.C.M.G., M.A., LL.B., delivered an illustrated lecture entitled "The University of Tasmania". This was followed by a Conversazione in the Art Gallery when Supper was served to approximately 200 people.

[It is hoped to publish the substance of this address in a later volume of the Papers and Proceedings.]

Errata

Spry A.—Tertiary Volcanic Rocks of Lower Sandy Bay, Hobart.

Page 153, line 2, *for* overly *read* overlie
Page 154, line 34, *for* bed *read bed*
Page 156, line 37, *for* spheriodal *read* spheroidal
Page 158, line 35, *for* pyroyene *read* pyroxene
Page 158, line 43, *for* cyrstals *read* crystals
Page 159, line 9, *for* oriental *read* oriented
Page 159, line 14, *for* 1948 *read* 1949
Page 159, lines 22, 26, 29, *for* 1933 *read* 1926
Page 160, line 6, *for* give *read* given
Page 162, line 29, *for* assymetrical *read* asymmetrical
Page 165, line 18, *for* assymetrical *read* asymmetrical
Page 165, line 25, *for* assymetrical *read* asymmetrical
Page 165, line 24, *for* anti- *read* syn-
Page 165, line 45, *for* the *read* that
Page 167, line 7, *for* assymetry *read* asymmetry
Page 167, line 12, *for* assymetry *read* asymmetry
Page 167, line 42, *for* Peninsular *read* Peninsula
Page 168, line 26, *for* fig. 3 *read* fig 6.
Page 168, line 29, *for* Auousseau *read* Auroussea.
Page 155, line 2, *for* 1851 *read* 1881

Dorothy Hill—Ordovician Corals from Ida Bay, &c.

Page 237, line 23, *for* Criaghead *read* Craighead
Page 245, line 32, *for* Blackriverian *read* Blackriveran
Page 250, line 37, *for* Specimens *read* Specimen
Page 254, line 26, *for* Port Cygnet *read* Southport

Banks, M. R., Hale, G. E. A., Yaxley, M. L.—The Permian Rocks of Woody Island, Tasmania.

Page 224, line 15, *for* Lewis point. Sandstone and . . .
read Lewis Point sandstone and . . .
Page 224, line 21, *for* facetted *read* faceted
Page 224, line 42, *for* aviculopectinids *read* aviculopectenids
Page 225, line 36, *for* Aviculopectinidae *read* Aviculopectenidae

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Notes on Tasmanian Mosses from Rodway's Herbarium: II

By

G. O. K. Sainsbury
Wairoa, New Zealand

Family DICRANACEAE

Rodway adopts a wide concept of this family and includes therein genera which in the Musci are referred to the separate families Ditrichaceae and Seligeriaceae. My preference is to recognise these families, and consequently in these notes *Pleuridium, Ceratodon, Ditrichum* and *Distichium* are included in Ditrichaceae and *Blindia* in Seligeriaceae, whilst the remainder of the genera mentioned by Rodway (other than *Tridontium* which is now of the Pottiaceae) go to make up the restricted family Dicranaceae, there being several alterations of generic names. *Leucobryum* is included here instead of being separated in the family Leucobryaceae, as I adopt LeRoy Andrews' view that this is the right place for it (*Taxonomic Notes VI; The Leucobryaceae;* The Bryologist, 50 : 319).

Family DITRICHACEAE

In this group the plants are small and erect with narrowly lanceolate leaves which are seldom falcate-secund and in which the alar cells are not differentiated. The capsule is erect and symmetrical, and the peristome usually consists of 16 narrow teeth divided to the base into two filiform papillose divisions. The operculum is shortly beaked.

PLEURIDIUM Brid. *P. nervosum* (Hook.) Par., a species occurring in South Africa, Australia and New Zealand, is not mentioned by Rodway, but there is barren material from near Launceston in his collection so named by Brotherus. It is queried by Rodway as being probably the male plant of *Bartramidula pusilla* (H. f. & W.) Schwaegr., but it certainly belongs here. It is a gemmiferous form which occurs in New Zealand and of which I have given some details (*Vegetative Reproduction in New Zealand Mosses;* Journ. & Proc. Roy Soc. N.S.W., 69 : 89). The same form is in the collection from Mount Nelson Range, and is also sub nom. *B. pusilla.* I have examined the type of *P. gracilentum* Mitt, which appears to be conspecific with *P. nervosum,* being a form, probably a habitat-modification, with longer stems and with leaves longer and more spreading and with longer points. I do not know *P. tenellum* Mitt., which Rodway also cites, but from the description I have little doubt that it is the same plant. It is not mentioned in the Musci. *P. nervosum* in New Zealand is usually found on bare earth, densely tufted. The lower leaves are appressed, the upper ones comose, and the reddish sessile cleistocarpous capsule is very conspicuous.

CERATODON Brid. In addition to the cosmopolitan *C. purpureus* Rodway also includes *C. stenocarpus* Bry. eur. as a Tasmanian moss. The Studies cites it also for New Zealand, but with subspecific rank only and reluctantly at that. Fleischer, in the Musci von Buitenzorg, treats it as a form of *C. purpureus*. I have not found the material in Rodway's collection to be helpful in delimiting the two species.

Ditrichum Timm.

D. elongatum H. f. & W. When in fruit this species is recognisable at once by the very narrowly cylindrical capsule which is pale except at the mouth and neck. Barren plants are sometimes difficult to separate from *D. punctulatum* in which, as here, the cells of the subula are very short.

D. punctulatum Mitt. This species is widely distributed in New Zealand, and is noted and described from Tasmanian plants at Navarre Plains and Mt. Field by Weymouth and Rodway (Papers & Proc. &c., 1921, p. 173). The capsule is oblong or elliptic and slightly widened at the base, and the peristome teeth are inserted under the rim, not on a projecting basal membrane as in the preceding species. When barren, *D. punctulatum* is usually known by the glossy subula which is spirally twisted when dry. In both plants the subula is irregularly dentate at the tip.

D. strictum Hampe. Syn. *D. australe* Mitt.

I have not seen any Tasmanian material attributable to this species, which has a subantarctic distribution. The Studies mentions the probability that not all the Tasmanian records belong to the true *D. strictum*, but it is given there as occurring in Tasmania. It differs from *D. punctulatum* in being a more robust, darker coloured plant with the leaves much more rigid. The leaf base does not show an abrupt shoulder, as in *D. punctulatum*, but gradually tapers to the subula the apex of which is often flattened out at the extreme tip. The capsule is small and pachydermatous.

D. flexifolium (Hook.) Hampe. Syn. *D. Oldfieldii* Mitt., *D. flavipes* C.M., *D. affine* C.M., *D. setosum* H. f. & W.

The two last-mentioned synonyms are treated as such in the Studies, and although I have not seen type material of either *D. Oldfieldii* or *D. flavipes* there are named specimens of both these species in the collection which are certainly referable to *D. flexifolium*. It is evidently the most common species in Tasmania, as it is in New Zealand, and it has a wide distribution in the southern hemisphere and in the tropics. As might be expected, the range of variation in the characters is wide. Rodway justly observes that the Tasmanian *Ditricha* with long cells could well be considered as forms of a widely distributed plant. Typically the capsule is long and ovate-cylindrical, slightly curved, asymmetrical and narrowed at the mouth, but sometimes it is much shorter and more symmetrical. The seta is usually long and is yellowish or reddish. The operculum has a suberect subulate beak, variable in length but seldom exceeding half the length of the capsule. The narrowly linear cells throughout separate it from all the other Tasmanian species.

Distichium Bry. eur.

D. capillaceum (Hedw.) Bry. eur. The habit here recalls that of *Ditrichum,* but the leaves are distichously arranged, at any rate in the upper part of the stem. The subula cells are variable in length but are mostly subquadrate. The roughness of the nerve at the back is a good diagnostic feature. The distribution is wide throughout the world.

Family SELIGERIACEAE

The only Tasmanian genus so far recorded is *Blindia,* which differs from the other genera in that the alar cells are usually differentiated. The homologous cells of the nerve, however, and the small wide-mouthed capsule are family characters which it exhibits, and the entire, or almost entire, peristome teeth are another supporting feature.

Blindia (Hedw.) Bry. eur.

Rodway's species call for radical alterations. *B. arcuata* and *B. robusta* are treated in the Studies as synonyms of *B. magellanica* and *B. tenuifolia* respectively, the plant known as *Anisothecium ferruginium* is now recognised as belonging to the present genus, and a recently published species is added. The following key to the species is in substitution for Rodway's in which *B. tenuifolia* is erroneously stated to be gymnostomous.

1. Plants short and slender, less than 1 inch high	2.	
Plants more robust, exceeding 1 inch	3.	
2. Seta arcuate, alar cells differentiated	1.	magellanica
Seta straight, alar cells not differentiated	2.	ferruginea
3. Nerve very robust, alar cells not differentiated	3.	tasmanica
Nerve weaker, alar cells differentiated	4.	tenuifolia

1. *Blindia magellanica* W. P. Schimp; Syn. *B. arcuata* Mitt.

The colour here is not blackish, as it often is in the genus. The subglobose capsule on an arcuate seta will distinguish it when in fruit, and vegetatively it is adequately described by Rodway, though the nerve cannot be said to be wide for the genus as mentioned there.

2. *Blindia ferruginea* (Mitt.) Broth. Syn. *Anisothecium ferruginium* Mitt.

The capsule here is also subglobose, but the seta is straight. The very short upper cells and the undifferentiated basal cells are vegetative characters to distinguish this species from the last.

3. *Blindia tasmanica* Sainsb. The Victorian Naturalist, 70 : 30.

This interesting species appears in the collection as *B. arcuata,* the locality given being Cradle Mountain. It is a rather robust blackish plant with stems attaining 4 cm. The leaves are falcate-secund, with narrow cells without a differentiated basal group, and an extremely robust nerve, about 150 μ wide, which occupies the whole of the rigid subula. The seta is stout and almost erect, the capsule short and wide, and the peristome teeth coarsely papillose above and mostly bifid at the tips. The operculum is adherent to the columella and has a long oblique beak. The calyptra is cucullate and reaches to the base of the capsule. The spores are 28-32 μ, smooth, pale green.

4. *Blindia tenuifolia* (H. f. & W.) Mitt. Syn. *B. robusta* Hampe.

This species is distinguishable from the last by the much weaker nerve and the coloured alar cells. It is a montane and more or less aquatic moss, widely spread in New Zealand. Rodway's collection contains a puzzling *Blindia* which is part of the Cradle Mountain gathering of *B. tasmanica* (No. 56A). As there, the columella adheres to the lid and the alar cells are not differentiated, but the leaves have very long filiform points and the nerve is narrow. In colour the plant is not blackish but yellowish brown. The nerve and areolation seem to preclude *B. tenuifolia,* but as this is a very variable moss Rodway's plant may possibly be an extreme form with, at any rate sometimes, a systylous capsule, in this respect agreeing with Australian material that I have seen.

Family DICRANACEAE

The family characters are narrow lanceolate or subulate leaves which are nerved and often falcate-secund. The leaf-cells are usually elongated below with the alar cells clearly differentiated. The normal "dicranoid" peristome is of 16 red teeth, transversely barred on the ventral face, and divided to about half their length into two or three forks, their dorsal surface being papillose above and vertically striolate below.

Bruchia Brid.

B. minuta Mitt. This tiny cleistocarpous moss is not represented in Rodway's collection, and from the Studies it would appear that the original and only specimen is at Kew. It is not mentioned in the Musci.

Cynodontium Schimp.

C. tasmanicum Broth. e Rodway. Rodway's description seems to be the only publication of this species, but as his volume is dated 1914 and the only specimen in his herbarium is dated 1922, this must be a subsequent collection by him at Blue Tiers, the original locality. The specimen has deoperculate and old capsules, and my general impression is that it is referable to *Campylopodium lineare* (Mitt.) Dixon. According to Rodway the leaf margin is thickened and doubly serrate, but I have found the serration to be very variable, often lacking altogether, and the leaf margin not thickened. The species is not mentioned in the Musci, and I think that the occurrence of the genus in Tasmania is doubtful.

Campylopodium C.M.

Small mosses that have the seta cygneous as in *Campylopus,* but differ in the setaceous leaves, narrow nerve and non-differentiated alar cells. The only species given by Rodway is a synonym.

C. euphorocladium (C.M.) Besch. Syn. *C. flexipes* (Mitt.) Broth. Differs from the next species in the leaves abruptly narrowed from a wide sheathing base, and with the margins entire except occasionally for some slight denticulation at the apex. It is widely distributed in the Pacific and East Indies and is fairly common in New Zealand.

Campylopodium lineare (Mitt.) Dixon. Collections from the West Coast are in the herbarium and attributed to the preceding species. The fruiting characters are similar, but in the present plant the leaves are gradually tapered from a narrower base and the subula is serrulate in its upper part. The cells of the subula usually have projecting transverse walls that make the leaf surface more or less scabrid. It has hitherto ranked as a New Zealand endemic, and is a rare montane moss.

Trematodon Michx.

T. flexipes Mitt. In Rodway's work this appears only as a synonym of *Campylopodium flexipes,* i.e., *C. euphorocladium,* but it is an entirely different plant. The confusion arose through a slip by Brotherus and is explained by Weymouth and Rodway (*Bryophyte Notes,* Papers & Proc. etc., 1921 : 173). In the present genus the capsule is very distinct in its long neck or apophysis, which in some species is several times the length of the spore-sac. The neck is often strumose at the base. *T. flexipes* is distinguished from the next by the peristomate capsule and smaller spores. Another character is the almost geniculately flexuose seta. It is a minute plant with stems 2-3 mm. long. The Musci gives New Zealand as its habitat though the species was published on Tasmanian material and has only been recently established as a New Zealand moss. It has been reported there from a few mountainous localities.

Trematodon Mackayi (R. Br. ter.) Broth. Syn. *T. Weymouthii* Bartr. & Dixon; Botaniska Notiser, Lund, 1937, p. 65.

This species was reported as new to Tasmania by Weymouth & Rodway (Papers & Proc. &c., 1921 : 173), it having been previously set up on New Zealand material. *T. Weymouthii,* which also occurs in New Zealand, has no marked separating characters and in my opinion is better treated as a form. *T. suberectus* Mitt., which is comparatively common in New Zealand and which has a more fully developed peristome than in *T. flexipes,* has not yet been reported from Tasmania, but to judge by the records of the other species, it could be looked for there with some prospect of success.

Dicranodontium Bry. eur.

D. tapes (C.M.) Par. I do not know this plant which apparently emanates from Deal Island. It is not mentioned by Rodway, but is recognised as a Tasmanian endemic in the Musci and Studies. The affinities of the genus are with *Campylopus* and *Dicranum.*

Dicranella W. P. Schimp.

Mitten's genus *Anisothectum,* which is kept up by Rodway and Brotherus, is now usually treated as a subgenus, at the most, of *Dicranella.* I am informed that Brotherus, in his herbarium, confines *A. crispum* (Schreb.) Lindb. to the northern hemisphere, and places in *D. Jamesonii* (Mitt.) Broth. all plants formerly determined by him as *A. crispum* or *A. Schreberi.* The one other species of *Anisothecium,* given by Rodway as *A. ferruginium* Mitt., is a Blindia, as already mentioned. In Rodway's herbarium there are several specimens of a *Dicranella perdivaricata* Burch., of which I have no information as to publication. Some of the

plants of it seem to belong to *D. Jamesonii*, and others might be a form of *D. vaginata* (Hook.) Card. If all the Tasmanian plants that I have seen are referable to D. *Jamesonii* then that species would appear to be much more variable in Tasmania than it is in New Zealand, but the condition and quantity of the material is not such as to allow satisfactory conclusions to be reached.

Dicranoweisia Lindb. This genus is aptly named, because the plants have an outward Weissoid appearance owing to the leaves being crisped when dry, whereas the capsule exhibits a weakly developed dicranoid peristome. Structurally the leaves often show the affinity with *Dicranum* by having the alar cells more or less differentiated and coloured.

Dicranoweisia antarctica (C.M.) Par. This is in the collection from Western Tiers, sub nom. *Distichium capillaceum*. It is in fruit and is certainly referable here. Mr. J. H. Willis has recently collected a barren plant on Mt. Field West which is probably this species. *D. antarctica* is taller than the next, the stems being 2-3 cm. high. The leaves are much longer, to 5 mm. and the alar cells are coloured and conspicuous. The peristome teeth are coarsely papillose, inserted under the rim.

Dicranoweisia microcarpa (H. f. & W.) Lindb. Syn. *Weissia microcarpa* H. f. & W. This is a much smaller plant than the preceding, the stems being less than 5 mm. high. The leaves are correspondingly shorter, barely reaching 2 mm. The upper leaf cells are, as there, subquadrate, but the alar cells are not differentiated. The areolation is curious in that the cells in midleaf often have rather sinuose walls. Those in the basal area are porose. The peristome teeth appear to be almost smooth, but the capsules seen were deoperculate and old and the teeth fragmentary. This species has not been found in New Zealand.

Holomitrium Brid.

H. perichaetiale (Hook.) Brid. There are no specimens of this in the collection, but Rodway and Brotherus include it as a Tasmanian moss, which in view of the wide distribution would be expected. It is a robust plant with stems attaining 5 cm. The leaves are strongly crisped when dry, and are narrowed from a wide base to a longer channelled subula. Normally the alar cells are enlarged and coloured, but sometimes they are scarcely differentiated. The upper cells are small, incrassate and isodiametrical. The perichaetium is very long sheathing, the capsule erect, subcylindrical and tapered to the mouth from a wider base, the peristome short and weakly developed. I have not seen the leaves undulate, as stated by Rodway, or the nerve excurrent in a long hair-point, and I suspect that he had some other moss in view.

Campylopus Brid. It is desirable to add to Rodway's generic description that the nerve here, which is usually very wide below, exhibits differences in structure on which are founded three subgenera. In *Eucampylopus* the nerve in section shows a dorsal group of stereid cells, the ventral cells being wide-lumened; in *Palinocraspis* there are stereid bands on both faces, i.e., both above and below the central guide-cells; whilst in *Pseudocampylopus* the cells are more or less homogeneous, without stereids. This is probably a classification that is more satisfactory than any other, but too much must not be expected of it. The

number of species that have been created on variations of the nerve structure in this genus is almost incredible. Rodway rightly comments that neither the colour of the plants nor the development of the hair-point should be unduly relied on.

Campylopus introflexus Hedw. Syn. *C. pudicus* (Hornsch.) Jaeg.

The main characters here are the reflexed hair-point, the wide nerve which is usually ridged dorsally in its upper part, the reduced alar cells and the basal area of hyaline colourless cells which runs out obliquely to the margin higher up the leaf. This last character is a particularly strong one, but it is exhibited in some other species, including forms of *C. clavatus*. The hair-point is sometimes not reflexed at all and occasionally is lacking altogether. The Studies (p. 90) is so sceptical about the standing of *C. pudicus* that I treat it as a synonym. In *C. introflexus* the ventral cells of the nerve in section are large and with a wide lumen. This species has a wide boreal and austral distribution.

Campylopus clavatus (R.Br.) H. f. & W. Syn. *C. insititius* H. f. & W. *C. Rodwayi* Broth.

An extremely variable species which is common in Australasia. When fruiting it is distinguishable at once by the subcylindrical capsule which is tuberculose at the base but otherwise smooth, symmetrical and pale brown. The peristome teeth are divided to the base into two filiform densely papillose segments, and so are far from being typically dicranoid. Barren plants often give trouble owing to the wide range of variation in the specific characters. Typically the plants are robust, with the leaves spreading above in dense comal tufts in fertile stems and erect and more or less appressed in barren ones. The nerve is about half the width of the leaf in its lower part, and is excurrent in a short hyaline arista. The basal areolation is very variable, there being sometimes present a distinct hyaline area similar to that of *C. introflexus*. The alar cells are usually developed into conspicuous auricles, but at times are practically suppressed. The nerve in section is intermediate in structure between *Eucampylopus* and *Palinocraspis* in that it exhibits, perhaps usually, some divisions of the ventral cells. Deciduous buds are often produced at the apex of the stem or branch. They are stellate, with widely spreading narrow leaves, and reproduce the plant vegetatively by developing a new stem from the growing point. This character is mentioned by Rodway for *C. Rodwayi,* two specimens of which are in his herbarium and show the buds in question. This is a common form of the species, and barren plants are often identifiable by the presence of the buds.

Campylopus torquatus Mitt. The stems here are slender and silky, with leaves that are narrowed to a very long capillary flexuose subula which is usually denticulate in the upper part and hyaline-tipped. The basal cells are rectangular and the upper ones irregularly four sided. There are no differentiated alar cells. The seta is erect, flexuose when dry, and the peristome dicranoid.

Campylopus arboricola Card. & Dix. This hitherto reputed New Zealand endemic is present in the collection, sub nom *C. capillatus,* and is indeed the first finding. The locality is Macquarie Island and the collector

G. B. Moore. The specimen is in fruit and has a sulcate capsule and dicranoid peristome. Vegetatively the species strongly resembles *C. clavatus,* but differs in the nerve of distinctly *Palinocraspis* structure, the section showing dorsal and ventral bands of stereids throughout the leaf, including the base. Moreover, the deciduous buds, which are frequently present, are of quite a different shape from those of *C. clavatus,* they being broadly pointed, abruptly cucullate and scabrous on the back.

Campylopus bicolor (Hornsch.) Hook. This and the next species differ from the preceding ones in having the leaves abruptly cucullate and without, or almost without, a hair-point. The present species is characterised by a very broad nerve and suppressed alar cells. In section the nerve has the ventrals wide-lumened, and this and other characters often (so far as my experience goes) cause considerable difficulties when it comes to separating the plants from epilose forms of *C. introflexus.* I have never seen authentic fruiting specimens.

Campylopus Kirkii Mitt. A very distinct species in the leaf cells which, with the exception of the basal ones which are hyaline and thin-walled, have a very narrow vermicular lumen and are extremely incrassate. The alar cells form inflated and coloured auricles, but they are tender and liable to be torn off when the leaves are dissected from the stem. The leaf apex is rounded and cucullate, without hair-point. The nerve is greatly broadened at the base, and in the upper part of the leaf fans out into the lamina on each side with short branches. It seems that this species has not been found fruiting in Tasmania, but fertile plants in New Zealand, which are rarely found, show that the capsule is narrowly oval and grooved, with a dicranoid peristome.

Doubtful species

Campylopus capillatus H. f. & W. Apart from the somewhat taller habit and larger leaves, there seems to be nothing to separate this species from *C. torquatus* except the presence of differentiated alar cells, but I doubt whether there is any hard and fast line to be drawn. Rodway, contrary to what is said of these cells in the Studies, states that there are no distinct alars in *C. capillatus.*

Campylopus subappressifolius Broth. & Geh. From Rodway's description and a specimen in his herbarium from Cradle Mountain, I should think that a form of *C. introflexus* was a possibility for this plant. I have not seen the hair-point " bent when dry " as he describes it, but the material received was small. If the hair-point is normally bent then in my opinion it would not be safe to rule out *C. introflexus* in the absence of fruit.

Dicranoloma Ren. All the species listed by Rodway in *Dicranum* have been transferred by one authority or another to Renauld's genus *Dicranoloma.* The boundary between the two genera, however, is indistinct, and the main separating character in *Dicranoloma,* i.e., the hyaline leaf border of narrow elongated cells, is inconstant. In other respects the characters are those of the family.

KEY TO THE SPECIES

1.	Nerve with two prominent dorsal ridges; leaves biplicate below	1. dicarpum
	Nerve and leaves otherwise	2.
2.	Nerve narrow and faint, 40 μ (wide (or less)) in its lower part	3.
	Nerve much wider and stronger	5.
3.	Leaves ovate, acute, rugose	2. eucamptodontoides
	Leaves lanceolate-subulate, not rugose	4.
4.	Perichaetium very long, reaching the capsule	4. perichaetiale
	Perichaetium much shorter	3. Billardieri
5.	Cells of subula very short, isodiametrical or nearly so	6.
	Cells of subula elongate	5. robustum
6.	Peristome well developed; seta short, 1 cm. or less	6. Menziesii
	Peristome short and irregular, seta long, 2 cm. or more	7. trichophorum

1. *Dicranoloma dicarpum* (Hornsch.) Par. Syn. *Dicranum polysetum* Hampe. The species is distinguishable not only by the plicate leaves, but also by the cells near the nerve in the subula being much shorter than those towards the margin. The upper part of the lamina and the whole of the subula are spinulose-dentate. The setae are aggregated, and I have seen as many as nine in a perichaetium.

2. *Dicranoloma eucamptodontoides* (Broth. & Geh.) Broth. Syn. *Dicranum eucamptodontoides* Broth. & Geh. The habit here is different from that of any other of the Tasmanian species. There is a strong resemblance to the New Zealand *D. obesifolium* (R. Br. ter.) Broth. and they are obviously closely related. In both the leaves are shortly and widely ovate-lanceolate, concave and cucullate at the apex, but in the New Zealand plant the apex is rounded and obtuse and the nerve is shorter than in the present species. The latter apparently has not been found in fruit. The leaves are wrinkled in the specimen that I have seen. The alar cells are strongly developed and the other cells are, as in the New Zealand species, porose throughout.

3. *Dicranoloma Billardieri* (Schwaegr.) Par. Syn. *Dicranum Billardieri* Schwaegr.; *Dicranum integerrimum* Broth. & Geh. A widely distributed austral species of very variable habit. The leaves may be either falcate or straight and the margins toothed above or almost, if not quite, entire. The nerve is narrow and thin. The alar cells are strongly developed and the cells of the subula are long and incrassate. The short and sheathing perichaetium has the inmost bracts almost constantly muticous. This last character, together with the weak nerve, distinguishes the plants from *D. robustum*. I agree with Rodway's statement that *D. integerrimum* is only an extreme form of the present species. I have been unable to find any satisfactory distinguishing features. I have not seen any of the varieties of *D. Billardieri* which are given by Rodway, and so cannot form an opinion as to their taxonomic value. The var. *angustinerve* is dealt with below.

4. *Dicranoloma perichaetiale* Sainsb. Victorian Naturalist; Vegetatively this is inseparable from *D. Billardieri*, but in fruit is distinguished at once by the extremely long perichaetium. The bracts are so long sheathing that they reach the capsule, and, unlike those of *D. Billardieri*, are tapered to a long setaceous subula. Rodway's collection does not contain any specimen of his var. *angustinerve* of the latter species, and

to judge by his description the present plant may belong there, but his account is not sufficiently full to settle the point. Moreover, although he states that the variety is common, his packet containing the new species, which he collected at Zeehan, is merely labelled " Dicranum sp.", which indicates that he was unfamiliar with the plant. The nerve in *D. perichaetiale* is very narrow, 25-30 μ wide below, the leaf margin obscurely denticulate in the subula, or even entire there, the cells elongate and incrassate, the alar cells large and the marginal cells of the lamina greatly narrowed and forming a distinct hyaline border.

5. *Dicranoloma robustum* (H. f. & W.) Par. Syn. *Dicranum robustum* H. f. & W.; *Dicranoloma pungens* (H. f. & W.) Par. This is an extremely polymorphous species and the wealth of forms exhibited in New Zealand is indescribable. Rodway's collection contains only a few specimens, nearly all of the var. *setosum* (H. f. & W.) Sainsb., so it would appear that the species is rare in Tasmania. It is distinguishable from *B. Billardieri* by the wider and stronger nerve (60 μ or more), the long, fine almost capillary subula, which is variably denticulate, and the aristate inner bracts of the perichaetium. The var. *setosum* (*Dicranum setosum* in Rodway's work) is a form with brittle leaves that are an adaptation for asexual reproduction.

6. *Dicranoloma Menziesii* (H. f. & W.) Par. Syn. *Dicranum Menziesii* H. f. & W. The green colour, short leaf base and very long setaceous subula, with its minute isodiametrical cells, are well-marked characters here. The leaves are erecto-patent with spreading points, rarely secund. The nerve is strong and wide, and the cells of the widened part of the lamina usually rather short. The seta is short, and often overtopped by the leaves.

7. *Dicranoloma trichopodum* (Mitt.) Broth.; Syn. *Dicranum trichopodum* Mitt. In the Musci this is a *Dicranoloma,* but in the Studies a *Dicranum.* The presence of a thin hyaline leaf border, though sporadic, would support its inclusion in the present genus, but the sporophyte has little in common with the other Tasmanian and New Zealand species, the capsule being erect, narrow and tapered from base to mouth, and the peristome being short and irregular. The seta is long, often extravagantly so. The subula cells are larger and less regular than in *D. Menziesii,* and the colour is light yellow rather than green, but otherwise there is a strong vegetative resemblance. I have not seen anything in Rodway's collection that can be referred here with certainty, and the species is not mentioned in the main work, but a specimen, presumably fertile, is reported by Weymouth and Rodway from Cradle Mountain and was determined by Dixon (Papers & Proc. &c., 1921 : 173), so there can be no doubt about the record.

Dicnemoloma Ren.

D. Sieberianum (Hornsch.) Ren.; Syn. *Sclerodontium pallidum* (Hook.) Mitt. The freely branched stems and straggling habit do not give the impression of a dicranoid moss, but the affinity is revealed by the numerous quadrate basal cells. The leaves are nerved nearly to the apex, and are narrowly hyaline bordered to far up the subula. A hyaline hair-point is sometimes present. The upper cells are short and coarsely

papillose on the dorsal face, the central basal ones being elongated and smooth. I have not seen the sporophyte, but in the genus the capsule is described as inclined and symmetrical, curved when dry, and the peristome teeth as bifid.

Leucobryum Brid.

Leucobryum candidum (Brid.) H. f. & W. The leaves here are whitish and spongy, and consist of a multistratose nerve that occupies which constitutes the true lamina. There are no differentiated alar cells, the whole width of the leaf, except for a narrow margin of hyaline cells and although the leaves are usually falcate there is nothing in their structure to indicate a dicranoid moss. The nerve consists of a median row of green chlorophyllose cells (" chlorocysts "), with ventral and dorsal layers of hyaline cells (" leucocysts "). The upper part of the subula is more or less rugose. The curved asymmetrical striate capsule, with its typically dicranoid peristome, leaves no doubt as to the real affinity of this moss. It is widely distributed and extremely variable in size and habit, but in countries where it is considered as being the only representative of the genus it can always be recognised at once by the colour and tissue of the leaves. Several varieties or subspecies are recognised, but the material that I have seen from Tasmania is referable to the typical plant.

Notes on Tasmanian Mosses from Rodway's Herbarium: III

By

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Family GRIMMIACEAE

Of the eight genera included by Rodway in this family only three, *Grimmia, Rhacomitrium* and *Glyphomitrium,* are now usually recognised as belonging here. The others are referable to Orthotrichaceae, and of the three species given by Rodway for *Glyphomitrium* one, *G. latifolium* Broth., is admitted by its author to be *Tridontium tasmanicum,* and the others are now included in the genus *Ptychomitrium.* Mosses belonging to Grimmiaceae are usually tufted and rupestral, with strongly hygroscopic leaves which are hyaline-tipped and which have sinuose walls. The seta is often arcuate and the peristome is single.

Grimmia Hedw. In this genus the stems are shorter and less branched than in *Rhacomitrium* and the teeth are not, or only slightly, divided. The plants usually form dense cushions on rock.

Grimmia apocarpa Hedw. Syn. *Grimmia mutica* Hpe. The Tasmanian race of this very widely distributed species shares with the New Zealand form the peculiarity that the columella does not constantly fall with the lid, this constituting a deviation from one of the specific characters. The development of the short hair-point is so variable that completely epilose forms hardly deserve any distinctive rank. This is the only Tasmanian species so far known that has the capsule immersed in the perichaetial leaves. The cells in midleaf, but only there, are often slightly sinuose.

Grimmia pulvinata (Hedw.) Sm. Syn. *Grimmia cygnicolla* Tayl. This species differs from the next in the darker colour, wider leaves, shorter basal cells and autoicous inflorescence. The operculum is variable in the shape of its beak, and plants having it shortly and bluntly beaked are referable to the var. *africana* (Hedw.) Dix. This is the usual New Zealand form. The leaves have long hyaline points which give the cushions a hoary appearance. There are a few specimens in the collection named *G. tasmanica* C.M., but this species is not kept up in Rodway's work as distinct from *G. pulvinata* and I have no doubt that it is valueless.

Grimmia trichophylla Grev. This is distinguishable from the last by the characters mentioned. The inner basal cells are narrowly rectangular, but those at the margin are usually shortened and widened.

Grimmia laevigata (Brid.) Brid. Syn. *Grimmia campestris* Burch.; *Grimmia leiocarpa* Tayl. The broadly triangular-ovate leaves, bistratose above and with plane margins, the wide rough hyaline points, and the wide thin nerve which fails below the apex, are strong gametophytic characters. The hoary cushions fall to pieces readily.

Grimmia ovalis (Hedw.) Lindb. According to Geneva Sayers (*The Bryologist,* 54 : 91) *G. commutata* Hueb. should be treated as a synonym of this species. It has not hitherto been recorded in Australasia but it occurs, though rarely, in South Africa. In Rodway's collection there is a specimen, sub nom. *G. leiocarpa,* from Huon Road, " Hill near Fern Tree ", which, though in immature fruit, can probably be referred here. It is quite distinct from any other Australasian species in the deeply concave lanceolate leaves, with plane margins and a long, stout, slightly denticulate hair-point. The nerve, though rather narrow, is distinct. The upper cells are obscure, bistratose, rounded and incrassate; the basal ones elongated, incrassate and slightly sinuose, with a conspicuous marginal band of numerous (8-10) rows of shortened and widened hyaline cells. It is to be hoped that further findings will clarify the plant's position.

Rhacomitrium Brid.

Rhacomitrium crispulum (H. f. & W.) H. f. & W. Syn. *Rhacomitrium symphyodon* Mitt. Rodway's statement that the leaf cells here are coarsely papillose and that the lower ones are without sinuose walls shows that he did not know this species, because the cells are smooth and those below have the walls extremely sinuose, i.e., nodulose. The Studies reduces *R. symphyodon* to synonymy and does not recognize the boreal *R. heterostichum* (Hedw.) Brid. as a Tasmanian or New Zealand moss, but treats the plants which had been included in it as referable to the present species. *R. rupestre* H. f. & W. is there reduced to a variety of *R. crispulum.* Although Rodway's herbarium contains plants that show an approach to the variety, as described in the Studies, I have not seen anything that is referable there with certainty. *R. crispulum* is almost always rupestral and appears to be as common in Tasmania as it is in New Zealand. It is very variable in habit, colour, &c.

Rhacomitrium lanuginosum (Hedw.) Brid. var. *pruinosum* H. f. & W. Syn. *Rhacomitrium pruinosum* C.M. *Rhacomitrium hypnoides* (Hedw.) Lindb. var. *pruinosum* H. f. & W. In one form or another this must be the commonest bipolar moss in the world. In New Zealand it is often, perhaps usually, terrestrial, but elsewhere its substrate appears to be rock. The diaphanous leaf-tip and hair-point, dentate and papillose, are distinctive and beautiful. The rough seta is unique in the genus. I have no information as to the frequency of fruit in the Tasmanian plant. In New Zealand fertile plants are extremely rare.

Ptychomitrium Fürnr. The position of this genus is not unanimously settled. The Musci, followed by Dixon in his *Classification of Mosses* (Manual of Bryology), places it in a separate family, Ptychomitriaceae, next to Orthotrichaceae. The plants differ from those of *Grimmia* in having the leaves without hair-points and the leaf cells without sinuose walls.

Ptychomitrium Mittenii Jaeg. Syn. *Glyphomitrium serratum* Mitt. This is amply distinct from the next in the leaves being strongly serrated above. It occurs in Australia but has not been reported from New Zealand.

Ptychomitrium acutifolium H. f. & W. Syn. *Glyphomitrium acutifolium* Mitt. This is a much smaller plant than the preceding, with a habit recalling that of *Weissia controversa,* with entire leaf margins

which are nearly plane and not revolute as described by Rodway. I have not found any obvious differences between this and small forms of the Australian and New Zealand *P. australe* (Hampe) Jaeg., and from what I have seen of the plants I am doubtful whether in this genus the relative lengths of calyptra and capsule are as firm a character as might be supposed from the divisions given in the Musci.

Family ORTHOTRICHACEAE

As in Grimmiaceae, the leaves here are hygroscopic, but they have no hyaline tip. The cells are often papillose and their walls are not sinuose. The peristome is normally double, but it is sometimes single or even lacking. The habit of the plants varies; in some genera (e.g., *Macromitrium*) the stems creep and emit many short branches, whilst in others (e.g., *Orthotrichum*) they are usually erect and sparingly branched.

Orthotrichum Hedw. The boundary between *Orthotrichum* and *Ulota* is indistinct, the two genera being kept apart more as a matter of practical convenience than on account of any very marked differences. Nevertheless, it is possible to separate the Tasmanian species of the present genus by the stomata being situated in the central or upper part of the capsule and by the inner cells of the leaf base being scarcely incrassate and little differentiated from the outer cells; whereas in *Ulota* the stomata are confined to the base of the capsule and the basal leaf cells are strongly incrassate and lengthened, and the outer cells (in several rows) are short, wide and hyaline, forming a conspicuous border. In both genera there is a well developed outer peristome of 16 teeth, often united in pairs, combined with more or less rudimentary processes which form the inner peristome. The three local species of *Orthotrichum* have the stomata superficial. It is more than likely that future collections will substantially increase the number of Tasmanian species.

Orthotrichum tasmanicum H. f. & W. Syn. *Orthotrichum laticiliatum* Vent. & Broth. This differs from the other species in the comparatively long seta which raises the capsule well above the perichaetial leaves. Rodway describes the leaf margin as revolute, but this is not constant in the species which is altogether extremely variable. The leaf cells may be papillose or almost smooth, the calyptra slightly hairy or smooth and the capsule ribbed or smooth. In the New Zealand race the seta is often greatly shortened so that the capsule is then almost immersed. I adopt Dixon's view (Studies, 175) that *O. laticiliatum* is not distinguishable.

Orthotrichum lawrencii Mitt. The affinity here is with *O. tasmanicum*, but the basal leaf cells are not much longer than the upper ones, as they are there, and the processes are wider and coarsely papillose. The capsule scarcely exceeds the perichaetial leaves. The locality of Gunn's original finding is not specified, and there has been no further collection.

Orthotrichum rupestre Schleich. This northern species is not mentioned by Rodway, but there is a specimen so-named in his herbarium, collected by him at Kangaroo Valley, which appears to be referable here. It differs from the foregoing in the immersed capsules, the broadly lanceolate leaves with margins regularly revolute to near the apex, and in the strongly papillose cells. In *O. rupestre* the inner peristome is

either wanting or rudimentary. The relationship between the northern plant and the New Zealand *O. pulvinatum* R. Br. ter. requires clarification, and further collections of the Tasmanian plant are much to be desired.

Ulota Brid.

There has been a modern and authoritative revision of the Australasian species of this genus by the late N. Malta (*A Survey of the Australasian Species of Ulota,* Act. Hort. Bot. Univ. Latv. VII, 1933), and as a result a total of six species is still recognised as Tasmanian, but three of Rodway's are omitted and replaced by new species. Students of the group will find the revision indispensable, and the following brief notice is merely intended to give the salient features by which the species can be recognised.

Ulota lutea Mitt. Syn. *Ulota Weymouthii* Vent.; *Orthotrichum crispum* Hedw. A marked character here is the leaf's " waist " which is formed by recurvature of the margins on both sides for a short distance immediately above the widened base. It is nearly always exhibited in some of the leaves. *U. crispa* (Hedw.) Brid., a northern species, is not given by Rodway for Tasmania but appears in the Flora Tasmaniae as *Orthotrichum crispum.* Malta considers both it and *U. Weymouthii* to be identical with the present species. He mentions that some of the plants hitherto referred to *U. fulva* Brid. belong to *U. lutea,* and that the former plant is confined to the Madagascar region and does not occur in Australasia.

Ulota laticiliata Malta. There is a close resemblance here to *U. lutea,* but the leaf margins are almost plane and the processes of the peristome are wide and often with a zigzag median line instead of being linear-lanceolate, as there. In both the leaves are strongly crisped when dry. *U. laticiliata* is widely distributed in New Zealand.

Ulota cochleata Vent. This is a Tasmanian endemic. It differs from the other species in having the stomata in the middle of the capsule. Rodway describes the leaves as partially crisped when dry, but Malta states that they are strongly twisted. He describes the processes as being filiform and knotted.

Ulota membranata Malta. This species is recognisable at once by the enormous spores which measure up to 90 μ in diameter, and which are sometimes multicellular. The capsule shape, too, is distinctive, it being almost pyriform. Another interesting fruiting character is the irregular praeperistome. *U. membranata* also occurs in New Zealand and is fairly common there on subalpine scrub.

Ulota Dixonii Malta. This and the following differ from the other species in the creeping habit and in the leaves being only very slightly twisted when dry. They also have in common a yellow-bordered operculum; but the present plant is more robust, with larger leaves that are gradually tapered from an oblong base, whilst in *U. viridis* they are narrowed more abruptly from a rotund or shortly oval base. The spores in the present species are verruculose, whereas in *U. viridis* they are finely papillose. *U. Dixonii* is endemic, but I have seen a New Zealand plant that is closely related and may possibly be a variety.

Ulota viridis Vent. Syn. *Ulota anceps* Vent. The distribution here is confined to Tasmania and New Zealand. Malta considers that *U. anceps* is only a robust form. *U. viridis,* as its epithet implies, has a green tint, and this, with the slender creeping habit and leaves appressed and but little altered when dry, makes it easy to recognise.

Macromitrium Brid.

Rodway's account of the species of *Macromitrium* shows that there has been considerable misunderstanding as to the identity of some of the species. The material that I have seen is scanty and imperfect, and though in some cases it includes part of the actual type, this does not compensate for the lack of adequate specimens in good condition, which alone can enable satisfactory conclusions to be reached in such a difficult genus. The following treatment is purely tentative and aims at doing little more than clearing the ground for future investigators.

Macromitrium asperulum Mitt. and *Macromitrium Archeri* Mitt. it will be noted that these two, as well as three other, species are given by Rodway as having papillose leaf cells, glabrous calyptras and gymnostomous capsules, an invitation surely for a close scrutiny! Through the courtesy of Dr. Rogers of the New York Botanical Gardens I have examined part of the type gatherings of these two species from Mitten's herbarium. In *M. asperulum* the leaves tend to be narrower and longer, being ligulate from a slightly widened base, whilst in *M. Archeri* the leaves are lanceolate and the base wider. Nevertheless, the differences are rather elusive. In both the leaf margin is more or less crenulate by projection of the cells which are variably papillose. This condition, which is described by Mitten as "erose", is more marked in *M. asperulum,* the name of which refers to this rough appearance of the leaf edge. In a footnote to the species in the Flora Tasmaniae Mitten mentions the erose leaf margin as a separating character from *M. Archeri,* but his Tasmanian specimen of *M. asperulum* has the leaf margin often scarcely crenulate, and moreover his diagnosis of *M. Archeri* describes the margin there as "minutissime eroso". Apparently then the difference here is only one of degree. Mitten states that the dry leaves in *M. asperulum* are incurved and that those in *M. Archeri* are twisted and subcrispate, but my impression is that in both type plants the leaf habit is the same, i.e., more or less crisped when dry. The two appear to agree in having a smooth calyptra and gymnostomous capsule, assuming that Rodway's statement concerning the latter is correct. The Studies gives *M. asperulum* as a synonym of *M. ligulare* Mitt., but the latter species appears to differ in the peristomate capsule and in the areolation of the leaf. New Zealand specimens which have been referred to *M. asperulum* are probably forms of *M. erosulum* Mitt. or *M. prorepens* (Hook.) Schwaegr. If *M. Archeri* and *M. asperulum* are to be united then the customary page priority would favour the former as the name.

Macromitrium pusillum Mitt. This is a difficult plant, owing to the imperfect condition of the few available specimens. The type collection was made "on stones; Cataract Hill". Mitten's diagnosis gives the calyptra as glabrous (and the material confirms this), but is silent as to the peristome which Rodway states is wanting. Mitten describes the dry leaves as spirally twisted, but I have not seen them strikingly so.

His specimen, and another from Circular Head determined by Brotherus, confirm his statement that the leaf edge is entire, lacking the crenulation which characterises the foregoing species. Otherwise the aerolation is much as it is in them, but the cells are only slightly papillose. The branches are very short and my specimens give the impression that they may be stunted plants. The Studies gives *M. pusillum* as a New Zealand moss, but there is no doubt that the plants which have been referred there really belong to *M. ligulare* Mitt. and that *M. pusillum* has as yet not been reported from New Zealand.

Macromitrium microstomum Schwaegr. In the note to *M. asperulum* in Flora Tasmaniae it is explained that owing to a confusion of specimens in Hooker's herbarium examples of *M. asperulum* have been referred to *M. microstomum,* a totally different species which is allied to the East Indian *M. Reinwardti* Schwaegr. This accounts for the fact that in Rodway's work, and in his herbarium, specimens of what is probably *M. asperulum* have been wrongly described and determined as *M. microstomum.* The same observation applies to what Rodway has taken to be *M. Weymouthii* Broth., but the error in this case must have arisen through a mixture of mosses sent in a folder from Rodway to Brotherus, which I have seen from the latter's herbarium, and which contains a small portion of the true *M. Weymouthii* together with what is probably *M. asperulum.* The only examples of the true *M. Weymouthii* in Rodway's collection appear there sub nom. *M. tasmanicum* Broth., and his description of the latter species is a fairly adequate account of *M. Weymouthii,* except for the fact that the capsule is peristomate as Rodway's own specimens show. Mosses of the *M. Weymouthii* group are quite distinct from those of *M. asperulum* affinity in the small strongly incrassate leaf cells which are smooth, or almost so, throughout, and in the entire leaf margin, quite without crenulation. The relationship between *M. Reinwardti, M. microstomum* and *M. Weymouthii,* which all belong to the same group, is by no means clear to me. According to Fleischer's Musci von Buitenzorg *M. Reinwardti* occurs in Tasmania, and this statement is also made in the Flora Tasmaniae. That might have been Fleischer's only source of information, but in any event his description of that species applies so well in many respects to *M. Weymouthii* that the possibility of their being conspecific suggests itself. Dixon, in the Studies (p. 187), observes that all the so-named specimens of *M. microstomum* at Kew belong to *M. Weymouthii,* and from this remark it seems possible that he did not appreciate the close relationship between the two species. I have examined a few leaves of the type gathering of *M. microstomum* from Greville's herbarium, and find that the aerolation is much the same as in *M. Weymouthii* though the leaves are more finely pointed in Greville's moss. If further research establishes that the three mosses concerned are conspecific then *M. Reinwardti,* as the earliest publication, would be the valid name. In my opinion *M. tasmanicum* is certainly the same moss as *M. Weymouthii* whatever the correct name of the latter should be.

Macromitrium longirostre (Hook.) Schwaegr. This has a distinct habit when dry, the leaves being somewhat spirally twisted round the stem with the points rigidly projecting, giving the stems a bristly appearance. The leaves are lanceolate, sharply pointed, with smooth

cells. The elongate, narrow, sulcate capsule is also distinctive. *M. Rodwayi* Dixon, which was published by Weymouth and Rodway subsequently to Rodway's main work (*Papers & Proc.* &c., 1921), seems to me to have much in common with the present species, but differs somewhat in the habit, the dry stems not being bristly. *M. Rodwayi* was collected at Port Arthur on maritime rock, the usual station for *M. longirostre* in New Zealand, but the latter species is probably corticolous in Tasmania and often so in the Campbell Islands group.

Macromitrium eucalyptorum Hpe. & C.M. The slender habit and the leaves appressed and strict when dry characterise this species very distinctly. Rodway's key states that the calyptra here is smooth, whilst in *M. microphyllum* Hook. & Grev. it is hairy. This is an error, because normally the calyptra in *M. eucalyptorum* is densely hairy but, at any rate in the New Zealand plant, the character is variable and sometimes the organ is almost smooth. *M. microphyllum* is a South African species and Sim, in the Bryophyta of South Africa, treats it as a form of *M. tenue* (H. & G.) Brid.; but whatever may be the true relationship between the Australasian and South African plant it seems clear that the only recognised Australasian species of the group is *M. eucalyptorum.*

Zygodon Hook. & Tayl.

Malta has revised this genus in a very valuable work (*Die Gattung Zygodon Hook. & Tayl.;* Lat. Univ. Bot., Riga, 1926), and has divided the species into three subgenera as follows:—*Bryoides* Malta where the leaf cells are smooth and to which *Z. Menziesii* and *Z. minutus* belong; *Euzygodon* C.M. where the leaves are acute and the cells more or less papillose and which includes *Z. intermedius* and *Z. Hookeri,* and *Obtusifolius* Malta where the leaf apex is rounded and the cells are papillose. All the Tasmanian species, and two others, occur in New Zealand.

Zygodon intermedius B. & S. Syn. *Zygodon Brownii* Schwaegr. Malta found that in this species, which has a wide distribution in the southern hemisphere, the Australasian plants show a gradual transition from double to single peristome, and that *Z. Brownii* cannot be considered as distinct merely on account of its double peristome. The capsules in *Z. intermedius* are indeed sometimes gymnostomous and the cilia are usually fugaceous. Rodway's collection contains a barren specimen from Colebrook which is labelled as this species but which is an *Anoectangium,* and is in all probability the same as the New Zealand *A. Bellii* Broth.

Zygodon Hookeri Hpe. Syn. *Zygodon anomolus* D. & M. Malta has shown that *Z. anomalus* is invalid in that the material consists of a mixture, and that the plants usually referred to it belong to *Z. Hookeri.* In his view this species is a subspecies of *Z. Reinwardtii* (Hornsch) Al. Br. In the latter, which is an East Indian and South American moss, the leaves are spinulose-denticulate at the apex and the inflorescence is polygamous, whereas in *Z. Hookeri* the leaves are nearly entire and the inflorescence is synoicous. This distinction, admittedly rather slight, is made in the Studies. Rodway's description of *Z. Reinwardtii* as having entire leaves is incorrect, and that species, at any rate in its typical form, must be excluded from the Tasmanian flora. In both species the leaf margin is undulate, but I have not found this to be constant in the New

Zealand plants. As might be inferred from the foregoing, the present species is not always easily separable from *Z. intermedius,* but as a rule the longer leaves, showing here and there a few spinose teeth, and the presence of antheridia at the base of the vaginula, will serve to place *Z. Hookeri.*

Zygodon obtusifolius Hook. The rounded leaf apex, coarsely papillose cells and short nerve make this a very distinct species. Its absence from the East Indies and Australia is interesting and puzzling in view of its distribution in Tasmania, New Zealand, central and south America, India and Ceylon. Malta reports the curious fact that some plants from New Zealand and Venezuela have the leaf apex subacute.

Zygodon Menziesii (Schwaegr.) W. Arn. This species is characterised by the oblong leaves, incurved and twisted when dry, with margins reflexed to above midleaf. The nerve usually fails below the apex, but occasionally it is percurrent or even shortly excurrent. The smooth cells are arranged in regular rows ascending obliquely from nerve to margin. The peristome is double and persistent.

Zygodon minutus C.M. & Hpe. Rodway states that this is not present in any available collection, but Malta refers to a Tasmanian finding by Gunn which he has studied. The original gathering was made in Australia. *Z. minutus* differs from *Z. Menziesii* in the leaves being more sharply pointed, with plane margins and an excurrent nerve. It is a smaller plant but is obviously closely related and has a similar double peristome.

Amphidium (Nees.) Schimp.

Brotherus and Malta have favoured treating this genus as of the family Dicranaceae, but other authors assign it to Orthotrichaceae and separate it from *Zygodon* by the almost immersed gymnostomous capsule.

Amphidium cyathicarpum (Mont.) Broth. This moss grows in soft tufts on damp shaded rock, and is easily recognisable by the crisped leaves and scarcely exserted, wide-mouthed, deeply grooved capsule. In the New Zealand race the leaf margin is usually entire, but some remote denticulation is considered to be a specific character and, according to Rodway's description and my own observations, it is exhibited in the Tasmanian plant. When barren this species is not always easy to separate from *Anoectangium Bellii,* but in the latter the nerve is rough at the back, the leaf margin is always entire, and the nerve in section has the guide cells ventral and not median as they are in *Amphidium.* When in fruit the *Anoectangium* is distinguishable at once by the long seta.

Notes on Tasmanian Mosses from Rodway's Herbarium: IV

By

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Family MNIACEAE

This family as treated by Rodway is very heterogeneous, and admittedly so. Modern systematists do not recognise any of his genera as being properly referable there, and would treat *Mnium*, which subsequently to the main work has been found to occur in Tasmania, as the only representative of the family in that country. *Leptostomum*, according to Andrews (*The Bryologist*, 54 : 217), should be a genus of Bryaceae. *Hymenodon, Rhizogonium* and *Goniobryum* are now included in Rhizogoniaceae and *Mittenia* is a monotypic genus of Mitteniaceae. The plants of Mniaceae, as now limited, are characterised by the short and wide cells, the leaves often bordered and frequently spinose-dentate, and the nerve seldom far excurrent. The peristome is Bryoid, but the capsule is not pyriform as it so often is in *Bryum*.

Mnium longirostrum Brid. Syn. *Mnium rostratum* Schrad.

A widely distributed species which was added to the Tasmanian flora by Weymouth and Rodway (Papers & Proc. 1921, p. 173), and which is fairly common in New Zealand, being semi-aquatic there on shady rock. The leaves are large, rounded at the apex and with a short apiculus. The margin is strongly bordered and is usually obscurely deniculate above. The nerve is continuous to the apex, the branches long and straggling, and the leaves distant and complanate.

Family AULACOMNIACEAE

A small family consisting of two genera, *Leptotheca* and *Aulacomnion*, both of which are represented in Tasmania and New Zealand. The species of the latter genus is not mentioned in Rodway's work but it is reported in Flora Tasmaniae.

Leptotheca Gaudichaudii Schwaegr.

In this plant there are often produced red-brown brood-filaments in the axils of the upper leaves. I have not seen them in Tasmanian specimens, but they are common in the New Zealand race. The nerve here is rather far excurrent and the leaf cells isodiametrical and smooth. The Musci lists another species from Tasmania, *L. Wattsii* Card. It is not mentioned by Rodway and I have not seen it.

Aulacomnion palustre Schwaegr.

The Flora Tasmaniae mentions that the material here is barren, with pseudopodia, and that the collector was Gunn, "Hab. Formosa". It is described as a slender plant with small leaves, perhaps specifically distinct. I have not seen any Tasmanian collection, but one of the two New Zealand plants that I have examined, and that Dixon considered was a new form, may be identical with Gunn's moss. The species is widely distributed in the northern hemisphere. It differs from *Leptotheca Gaudichaudii* in the nerve failing below the apex and in the markedly papillose cells. As the epithet suggests, it is a hygrophilous moss.

Family RHIZOGONIACEAE

The leaves here are usually toothed, with the margins often thickened. The nerve is strong and the leaf cells mostly small and rounded-hexagonal. Except in *Hymenodon* the peristome is double, as in *Mnium.*

Hymenodon piliferus H. f. & W.

In this delicate little moss the leaf ends in a long fine hair-point. The nerve, though normally failing below the apex, occasionally is produced into, and fills, the hair point. The cells are rounded-hexagonal and mamillose. The outer peristome is wanting, and the inner consists of 16 narrow subulate processes, strongly vertically striate.

Rhizogonium Brid.

A genus that illustrates the artificiality of a primary division into acrocarpous and pleurocarpous mosses. There is a clear affinity with the acrocarpous Mniaceae, but the fruit in *Rhizogonium* is lateral or basal. The leaf cells are isodiametrical, and rounded or irregularly hexagonal. All the Tasmanian species, except perhaps *R. spiniforme,* occur in New Zealand.

Rhizogonium pennatum H. f. & W. The variety *aristatum* (Hpe.) Dixon replaces *R. aristatum* Hpe. which is given by Rodway as a separate species. The Studies (p. 220) suggests that varietal rank may be too high for it. *R. pennatum* resembles *R. distichum* and *R. novae-hollandiae* but differs from both in the stout cartilagenous leaf border and also from *R. distichum* in the excurrent nerve. It is a rare species in New Zealand.

Rhizogonium novae-hollandiae Brid. In the New Zealand plant the leaves when dry are usually distinctly secund, and from Rodway's description this is sometimes the habit in the Tasmanian plant. The leaf often has an indistinct border of 2-3 rows of narrower cells.

Rhizogonium distichum Brid. The serration of the leaf is coarser here than in the two preceding species and the nerve vanishes beneath the apex. There is no trace of a border.

Rhizogonium bifarium (Hook.) Schimp. This is distinct from all the other species in the dendroid habit and in the dimorphism of the leaves, those of the stem being lanceolate or almost subulate and those of the branches being ovate-lanceolate, smaller and relatively wider, and more or less distichous. It is an attractive moss and is very common in New Zealand on logs in the bush.

Rhizogonium mnioides (Hook.) Schimp. In this species the stems are robust, the leaves much crisped when dry, lanceolate-subulate with the margins thickened and doubly toothed nearly to the base. The position of the seta is lateral and the inflorescence is dioicous, whereas in *R. spiniforme* the sporogone is basal and the inflorescence is synoicous.

Rhizogonium spiniforme (Hedw.) Brid. I have seen the collection from Tasman's Peninsula cited by Rodway, and think that it is certainly referable here. The record from New Zealand seems to be rather doubtful. The leaves are not crisped when dry as in the last species, but are rigid and only slightly altered.

Goniobryum Lindb.

Modern research has established that this genus is monotypic, the character of the serrature of the leaf-margin, single in *G. subbasilare* and double in *G. pellucidum,* being inconstant. The lax areolation is unique in genera of Rhizogoniaceae, and this, with the dendroid habit and dimorphic leaves of *R. bifarium,* shows, according to Fleischer, a link between that family and Hypnodendraceae.

Goniobryum subbasilare (Hook) Lindb. Syn. *Goniobryum pellucidum* (Mitt.) Broth. As mentioned above, the toothing of the leaf margin here is variable, it being sometimes single and sometimes double. From Rodway's account it would appear that in the Tasmanian plant, which I have not seen, the serrature is single. The cells are lax and thin-walled, elongate-hexagonal or rhomboid. There is no thickening of the leaf margin. The distribution is Australasian and Fuegian.

Family MITTENIACEAE

Bartram and Dixon (in *Berggren's New Zealand Mosses,* Lund, 1937), have shown that this is a monotypic family, the sole species being *Mittenia plumula* (Mitt.) Lindb. with which *M. rotundifolia* (C.M.) Par. is conspecific. It is a very distinct little moss in the leaves often distichously arranged and widely and far decurrent on the lower side of the leaf base. The peculiar peristome consists of very long filiform outer teeth and short nodulose processes. *M. plumula* is found also in Australia and New Zealand.

Family FISSIDENTACEAE

Though three other genera are recognised in the Musci, there is now a tendency to treat *Fissidens* Hedw. as the sole genus of this very characteristic family. The plants, which are exclusively terrestrial, are recognisable at once by the peculiar structure of the leaves which are distichous, flattened and vertically directed. They clasp the stem in their lower part, the two clasping blades (" vaginant lamina ") constituting the true leaf. Above this lamina is a continuation (" upper lamina ") which extends to the leaf apex on the inner side of the nerve. On the back of the nerve a wing (" dorsal lamina ") extends from the apex to, or nearly to, the leaf insertion. The leaf is usually nerved and is either entirely unbordered or wholly or partially provided with a hyaline border which is often thickened. The cells are hexagonal or rounded. The capsule is small and the peristome more or less dicranoid. The following key to the species of *Fissidens* is in lieu of that of Rodway.

1. Leaves without nerve	1. dealbatus
Leaves nerved	2
2. Leaves with a hyaline border throughout	3
Leaves incompletely bordered	5
Leaves unbordered	7
3. Plants robust, semi-aquatic, border stout	4. rigidulus
Plants smaller, border narrower	4
4. Leaf cells small and obscure, similar throughout the leaf	3. leptocladus
Cells larger, pellucid, lax and elongate in the vaginant lamina	2. pungens
5. Plants minute; border on vaginant lamina only; dorsal lamina narrowed in fertile stems	5 Taylori
Plants larger; border intra-marginal on vaginant lamina	6
6. Cells very small (ca. 6 μ) and obscure; leaves sometimes faintly bordered on other laminae	6. vittatus
Cells larger (ca 10 μ) and pellucid; border on vaginant lamina sporadic, more often wanting	7. integerrimus
7. Plants small, 1 cm. high or less	8
Plants taller	10
8. Vaginant lamina crenulate-denticulate	8. tenellus
Vaginant lamina entire	9
9. Aquatic. Leaves rigid, strict and fleshy, apex obtuse	9. strictus
Leaves of thinner texture; apex acute, recurved or incurved when dry	10. pallidus
10. Leaves sharply toothed above, with pale but not hyaline border	13. adianthoides
Leaves entire	11
11. Leaves with apex obtuse and inrolled when dry	11. asplenioides
Leaves with more acute apex, only slightly altered when dry	12. oblongifolius

1. *Fissidens dealbatus* H. f. & W.

There has been a recent finding of this species in Fiji, and it also has a New Zealand distribution. The nerveless leaf and large cells place it at once.

2. *Fissidens pungens* Hpe. & C.M.

Rodway compares this species with *F. Taylori* C.M. and *F. semilimbatus* C.M. & Hpe., but those plants, which are probably conspecific, belong to the section *Heterocaulon* C.M. where the border is only on the vaginant lamina and the dorsal and upper laminea are reduced or suppressed, whilst in *F. pungens*, and other members of the section *Bryoidium* C.M., the leaves are bordered throughout and the laminae are fully developed. J. H. Willis's investigations have shown that *F. pungens* is the earliest publication of a number of Australian species which should be treated as synonyms, and that the New Zealand *F. campyloneurus* C.M. & Beck. is one of them. *F. pungens* is variable, especially in the length and width of the leaf and the length of the seta, but the clear subhexagonal cells and well-developed border are character by which it can usually be recognised without difficulty.

3. *Fissidens leptocladus* C.M. e Rodway. Syn. *Fissidens rigidiusculus* Broth. Proc. Linn. Soc. N.S.W.; 41 : 577.

As Rodway rightly observes, the leaf cells here are characteristic. They are dark, obscure and isodiametrical, about 6 μ as against 10 μ in *F. pungens*. The border is often thin and indistinct, never as stout as it is there. The leaves are often falcate and secund when dry, especially in tall forms. *F. leptocladus* was treated by Brotherus as a variety of his *F. rigidiusculus*. I have not seen specimens of the latter, but from

the description I have no doubt that it comes within the scope of *F. leptocladus*. Brotherus evidently overlooked Rodway's previous publication of Muller's species; otherwise he would have published *F. rigidiusculus* as a variety of it. I do not think that *F. gonioneurus* C.M. e Dixon (Studies, 102) is more than an inconstant form of the present species.

4. *Fissidens rigidulus* H. f. & W.

A robust moss with stems sometimes attaining 5 cm. The leaves are falcate-incurved and twisted when dry, stoutly bordered practically throughout. The cells are dark and opaque. It is more or less aquatic, and often forms dense mats on wet rock. *F. rigidulus* belongs to the section *Pachylomidium* C.M. which is characterised by the bistratose or multistratose leaf-border. It is found in Australia, New Zealand and Chile.

5. *Fissidens Taylori* C.M. Syn. *Fissidens brevifolius* H. f. & W.; *Fissidens semilimbatus* C.M. & Hpe.; *Fissidens elamellosus* Hpe. & C.M.

The Studies reduces *F. brevifolius* to this synonymy, and from what I have seen of Tasmanian and Australian specimens of the two others mentioned I can find no reason for keeping them apart. The areolation is as in *F. pungens* and the plants are very small, as there. In both species the forks of the peristome teeth are spirally thickened, but in the present species the teeth are sometimes not forked but are either entire or cracked on the median line. In the fertile plant the reduction of the upper and dorsal laminae is often very striking, the leaf then being almost entirely composed of the vaginant lamina.

6. *Fissidens vittatus* H. f. & W.

A well-marked species, the vaginant lamina being greatly inflated and its border being distinctly intramarginal in the lower part. The leaves are widely oblong, shortly pointed, and apiculate through the projecting nerve, incurved and falcate when dry. The cells are very dense and obscure. Rodway mentions that the leaf margin is obscurely serrate, and I have seen here and there in my only specimen of the Tasmanian plant some vague notching towards the apex, and also some denticulation in the upper part of the vaginant lamina. In the New Zealand race, where fertile plants have not been found, the leaf margin is quite entire.

7. *Fissidens integerrimus* Mitt. *Fissidens tasmanicus* Broth. e Rodway (Papers & Proc. &c., December 1915).

Confusion has arisen concerning this species owing to Mitten having described the leaf as "immarginata" in Flora Tasmaniae. He overlooked the fact that the lower part of the vaginant lamina is sporadically and intramarginally bordered by a band of narrow cells. The type specimen, which I have seen from his herbarium, shows some of the leaves distinctly so bordered, though the great majority of them are unbordered throughout. Rodway's description of the plant mentions the border and is quite adequate in other respects, but his statement that the locality is not recorded is incorrect because the Flora Tasmaniae and the type specimen's label both mention that the locality was Cheshunt and the collector Archer. Further, Rodway's note might imply that

fruit is unknown, whereas it is partially described in the diagnosis and is present in the type collection. *F. tasmanicus* is distinguished by Brotherus from *F. strictus* H. f. & W. by having the border in question, but both the description and what is evidently part of the type in Rodway's collection fit *F. integerrimus* perfectly. The peristome teeth, the forks of which are spirally thickened, support the view that the plant cannot belong to the section *Amblyothallia* C.M. where the Musci places it, on account of course of the supposed absence of leaf border. Its position in the genus is doubtful since the cells are too large and clear for *Semilimbidium* whilst the sporadic and partial border would exclude *Bryoidium*. The distribution is confined to Tasmania.

8. *Fissidens tenellus* H. f. & W.

This little moss is recognisable at once by the absence of border, the regular crenulation of the leaf margin and the frequent denticulation of the upper part of the vaginant lamina. The cells are pellucid and singly papillose. It is found also in Australia and New Zealand.

9. *Fissidens strictus* H. f. & W.

This is a small aquatic species with crowded, suberect, rigid leaves, unaltered when dry and of a fleshy consistency. They are unbordered and rather obtuse, sometimes minutely crenulate in the upper part. The leaf texture gives the cells the appearance of being bistratose towards the nerve. They are irregularly angled and subisodiametrical, noticeably larger near the nerve and there sometimes attaining 18 μ. The species was recently collected by J. H. Willis in Victoria, the first record for Australia. It has not been reported in New Zealand.

10. *Fissidens pallidus* H. f. & W.

This is a pale yellowish moss and differs from *F. strictus* in the acute leaves being strongly incurved or recurved when dry, not strict and rigid as there. The leaf tissue is thinner than it is in *F. strictus* and the margin is not crenulate but quite entire, except, according to the Studies, for some subdenticulation at the apex which I have not seen. Rodway's erroneous statement that the margin is very minutely serrate from cell protuberances was probably caused by confusion of material with *F. asplenioides,* and this supposition is supported by his referring *F. ligulatus* H. f. & W. to the present species, because both Fleischer, in the Musci von Buitenzorg, and Dixon, in the Studies, cite *F. ligulatus* as a synonym of *F. asplenioides*. A further difference between *F. pallidus* and *F. strictus* is that in the former the nerve is thin and colourless, whereas in the latter it is yellowish or red. *F. Whiteleggii* C.M., from Mt. Bischoff, seems to be a tall form of the present species, there being apparently no structural differences.

11. *Fissidens asplenioides* Hedw.

This species has been confused with *F. oblongifolius* and a number of Rodway's specimens are wrongly named as the latter. Several collections merely labelled "*Fissidens*" are also of *F. asplenioides*. The two mosses are much alike, and in both the leaves are obtuse or bluntly acute, with the margins variably crenulate by projection of the cells. The areolation is similar, the cells being rounded and slightly papillose (about

8 μ). The present species differs from *F. oblongifolius* in the leaves when dry being circinately inrolled at the apex, in the junction of the blades of the vaginant lamina being at the nerve and not at the leaf margin, as there, and in the dioicous inflorescence. *F. asplenioides* has a very wide distribution in the Southern Hemisphere. The Musci does not cite it for Tasmania, but Fleischer does.

12. *Fissidens oblongifolius* H. f. & W.

According to Rodway this species is very common in damp gullies, but as he had confused it with the last species it may be as rare there as it is in New Zealand.

13. *Fissidens adianthoides* Hedw.

A very distinct species in the robust habit, leaves irregularly serrate in their upper part, and lateral seta. The cells are large, ca. 18 $\times$ 12 μ, and a few rows at the margin are often paler and incrassate, forming an indistinct border. This species is widely distributed in the Northern Hemisphere, but in the southern it is confined to Tasmania and New Zealand, and, according to the Studies, possibly southern Australia. Dixon has pointed out that the specific epithet should be spelt as above, i.e., with an "h".

Family BRYACEAE

The following key to the genera of this great family is based on Andrew's treatment of it in Grout's North American Mosses. The plants are accordingly divided into two groups, *Pohlioideae* and *Bryoideae*, the former having narrow leaf cells, leaves mostly unbordered and often denticulate, and a peristome with cilia either wanting or imperfectly developed. In the *Bryoideae* the leaf cells are wider, the margin is often bordered, and the peristome has complete and often appendiculate cilia. This division is by no means hard-and-fast, but it seems to recognise two natural groups. I also adopt Andrews' view that the genus *Leptostomum* is properly referable to this family, and that *Mniobryum* should be included in *Pohlia*.

Key to the Genera

1.	Leaf cells usually elongated 4 $\times$ 1 or longer	2. (*Pohlioideae*)
	Leaf cells usually broader, less than 4 $\times$ 1	5. (*Bryoideae*)
2.	Fruit from base of stem; outer peristome lacking or rudimentary	1. Mielichhoferia
	Fruit terminal; outer peristome present	3
3.	Inner peristome without basal membrane; processes narrow	2. Orthodontium
	Basal membrane high; processes well developed	4
4.	Leaves setaceous; nerve wide	3. Leptobryum
	Leaves wider; nerve narrower	4. Pohlia
5.	Capsule erect or suberect; peristome more or less rudimentary; without cilia	6
	Capsule more or less pendulous; processes normal	6. Bryum
6.	Leaves with a long hair-point; cells subquadrate or rounded; peristome consisting only of a low projecting membrane	7. Leptostomum
	Leaves without a hair-point; cells rhomboid-hexagonal; peristome with outer teeth and processes	5. Brachymenium

1. *Mielichhoferia* Hornsch.

Only one species has been reported from Tasmania, and it has an Australasian and South African distribution. The long seta springs from the apex of a very short lateral branch at the base of the stem. The leaves are lanceolate, mostly denticulate at the apex, and the cells are narrowly linear-rhomboid.

Mielichhoferia Eckloni Hornsch. There is considerable variation in the peristome of this species. Normally there is no trace of an outer peristome, except for a basal membrane which is visible above the mouth, and the processes of the endostome are appendiculate and sometimes anastomosing. There are, however, deviations from this structure, and sometimes rudimentary outer teeth are developed, or the processes may be only slightly appendiculate or even without appendages. The inflorescence is paroicous.

2. *Orthodontium* Schwaegr.

As Rodway mentions, there is here a superficial resemblance to *Weissia*. The appearance of the plants is so different from that of Bryoid mosses in general that the impression is received that the genus may be out of place in that family. This was Fleischer's view, he being inclined to treat *Orthodontium* as a genus of *Meesiaceae*. The plants are small and delicate, with long narrowly linear-lanceolate leaves that are spreading and flexuose, linear-rhomboid cells and a fairly wide slender nerve which is either continuous or lost below the apex. The capsule is erect or inclined, borne on a slender seta and often ribbed. The peristome is double, poorly developed and with the teeth often shorter than the processes. The inflorescence is various, usually autoicous in Tasmanian plants. The genus has recently been revised by W. Meijer, and his treatment of the local plants is shortly as follows. The Australasian *O. sulcatum* H. f. & W. is reduced to a subspecies of the South African and European *O. lineare* Schwaegr., which is the type species of the genus. The antarctic species *O. australe* H. f. & W. is considered to be indigenous in Tasmania in the forms of subspecies *australe* Meijer and subspecies *robustiusculum* (C.M.) Meijer. *O. lanceolatum* Mitt. is considered to be a small form of *O. sulcatum* and falls into synonymy accordingly, and *O. pallens* (H. f. & W.) Broth. is added to the Tasmanian flora. Meijer has shown that the plication of the capsule is not a reliable character in the genus, and the Studies (p. 198) voices the same opinion where the question of the separation of *O. sulcatum* and *O. australe* is discussed. The revision would keep the two apart by the longer seta, more oblong capsule, peristome tending to equal length of outer and inner teeth, and broader nerve in *O. australe,* subsp. *australe*. For myself I incline to the view that, since the striation of the capsule is unreliable, there are no differences sufficiently definite to warrant a separation, and as in my opinion they are both merely local races of *O. lineare* I would merge them in that species. It will be noted that Rodway considered *O. sulcatum* as doubtfully distinct from *O. australe,* and that he probably did not compare them with *O. lineare* because he was unaware that in the latter the capsule is sometimes grooved. Muller's *O. robustiusculum* is characterised by the longer seta and larger capsule, the latter attaining a length of 3·2 mm. as against a maximum of 2·5 mm. It is certainly

rather a striking plant in that respect, though many species of bryoid and other mosses show equally well-marked deviations, but if it is to be kept distinct on account of these features then I think that it should be treated as a subspecies or variety of *O. lineare*. *O. pallens* is described as resembling broad-leaved forms of *O. sulcatum*, and is distinguishable by the short seta, small pyriform capsule, undeveloped processes of the endostome, and large spores (20-25 μ). It is in Rodway's herbarium, sub nom. *Apalodium lanceolatum*, from Gordon, and Meijer cites it from " Forest near Leprena, South Coast, Recherche ". There seems to be no reason to doubt its specific status.

3. *Leptobryum* Wils.

Leptobryum pyriforme (Hedw.) Schimp. A typically bryoid capsule and peristome are combined here with linear-setaceous leaves having narrowly linear cells and a wide indistinct nerve. The capsule, which is reddish brown and glossy, is of an extreme pyriform shape, the neck being narrowed and quickly tapered and the capsule itself being almost globose. The distribution is almost cosmopolitan. *L. pyriforme* is noted for its habit of colonizing flowerpots in greenhouses.

4. *Pohlia* Hedw.

In this genus the stems are either simple or with basal shoots or innovations from various points on the stem. The leaves are densely arranged and elongated in the fruiting comal part. They are unbordered, denticulate at the apex, with the nerve usually percurrent or failing, and with the cells mostly narrow. In the Tasmanian species the cilia are well developed though not appendiculate. They are often imperfect, or even lacking, in the genus.

Pohlia tasmanica (Broth.) Dixon. Syn. *Mniobryum tasmanicum* Broth. In a former paper (*Synonyms of some New Zealand Mosses*, Rev. Bry. & Lich., 17 : 82) I proposed the reduction of this species to a variety of *P. albicans* (Wahl.) Lindb. I formed this opinion after examining New Zealand forms of what the Studies has treated as *P. tasmanica*, including some specimens so determined by Dixon. I have since had the opportunity of studying the Tasmanian plant in Rodway's herbarium (a metatype from Newtown Falls, No. 142, p. p.) and have come to the conclusion that it should not, so far as can be judged from the available material, be considered as identical with the New Zealand plant. The leaves are narrowly lanceolate or linear-lanceolate and long acuminate, and the cells measure up to about 14 $\mu \times 200$ μ. The leaves are therefore too narrow for those of *P. albicans* and the cells are too long and narrow. Some of the New Zealand plants cause great difficulty owing to their colouring and areolation, but in the meantime I think that it is advisable to withdraw the variety and treat the Tasmanian species as endemic. The stems are 2 cm. high or shorter, simple or branched above by innovating shoots, and tinted here and there a vinous red. It is evidently hygrophilous.

Pohlia nutans (Hedw.) Lindb. This species is marked by the pale, more or less pendulous capsule, and by the paroicous inflorescence. From the specimens that I have seen in Rodway's collection it seems that the Tasmanian plant, like the New Zealand, often has a very long seta. A

variety *longiseta* Huebn. was set up on this character, but combined with long leaves and larger capsules. In both the Tasmanian and the New Zealand forms, however, a long seta may be combined with short leaves and capsules. The species is almost cosmopolitan.

Pohlia cruda (Hedw.) Lindb. Apparently this species has not been found fruiting in Tasmania. It is recognisable at once by the metallic sheen of the leaves which are yellow-green above and more or less vinous red below, ovate, acute, and with very narrow and elongated cells. It has a wide distribution in the Northern and Southern Hemispheres and occurs in Australia and New Zealand.

5. *Brachymenium* Hook.

A genus where the plants have the habit, leaves and leaf cells of *Bryum*, but in which the capsule is erect and narrow-mouthed and the inner peristome is shorter than the teeth, with the processes rudimentary and usually without cilia.

Brachymenium Preissianum Hpe. This little moss is scarcely distinguishable from a *Bryum* when barren, but it usually fruits freely, The operculum is rather highly conical, sometimes indeed almost rostellate. The suberect capsule with its constricted mouth and greatly widened base is characteristic. Rodway states that the endostome membrane has long slender cilia, but this is incorrect because the cilia are wanting. The structures seen are the processes which in this species are unusually well developed and nearly equal the teeth in height. *B. Preissianum* is fairly common in New Zealand, the usual substrate being calcareous rock.

6. *Bryum* Hedw.

In dealing with this, one of the most difficult of all moss genera, Rodway was at a particular disadvantage in not having the Studies to assist him in the treatment of polymorphous groups in the genus, and consequently in failing to appreciate the salient features of the different species and to realise the extent of variation in their vegetative characters. My own investigation has been restricted by the quantity and condition of the available material, so the conclusions reached are mostly tentative. The following key to the species is in substitution for Rodway's, and the species are dealt with in their order as appearing in the key.

KEY TO THE SPECIES

1.	Cilia imperfect, not appendiculate	curvicollum
	Cilia appendiculate	2
2.	Leaves with silvery points	argenteum
	Leaves not silvery	3
3.	Leaves distinctly bordered	4
	Leaves without border	9
4.	Leaves reddish, very obtuse; nerve failing below apex	blandum
	Nerve percurrent or very shortly excurrent	laevigatum
	Nerve excurrent in a hair-point or arista	5
5.	Leaves soft, sometimes spirally twisted round the stem; nerve far excurrent	capillare
	Leaves firm; arista stoutish, not markedly flexuose	6
6.	Inflorescence usually synoicous	7
	Inflorescence dioicous	8
7.	Nerve usually shortly excurrent; leaves acute	pseudotriquetrum
	Nerve rather long, cuspidate; leaves acuminate	affine
8.	Leaves finely acuminate	caespiticium
	Leaves wider and shortly pointed	Billardieri

9.	Nerve percurrent or very shortly excurrent; leaves ovate-oblong and widely acute	10
	Nerve far excurrent in an arista or cuspidate point; leaves lanceolate (except in *B. campylothecium*)	11
10.	Leaves large, usually exceeding 2 mm. long, often much larger, not comose	laevigatum
	Leaves much smaller; comose	crassum
11.	Leaves small, 1·5 mm. long or less, lanceolate or ovate-lanceolate; ripe capsule tinted dark purple	12
	Leaves larger, 2-3 mm. long, comose and imbricated, broadly obovate-oblong; ripe capsule brown	campylothecium
12.	Capsule narrowly clavate; leaves yellowish; nerve golden	chrysoneuron
	Capsule turgidly elliptic or barrel-shaped	13
13.	Capsule mostly constricted below the mouth; neck shortly tapered, not corrugated when ripe	dichotomum
	Capsule like an acorn in its cup; neck corrugated, not tapered	pachytheca

Bryum curvicollum Mitt. The main features here are the curved neck of the capsule and the more or less imperfect processes, the cilia only rarely being appendiculate. As Rodway correctly states, the capsule is not always conspicuously long or bent. The leaves are normally acute, with the nerve excurrent in a stout point, but those of the innovations are less sharply pointed, sometimes obtuse, and with the nerve often merely percurrent or even failing below the apex. In New Zealand this moss thrives on damp rock faces, and the capsule, usually dark coloured, makes it easily recognisable. The inflorescence is dioicous. *B. laevigatulum* Broth. is probably best treated as a form of *B. curvicollum* which is a very variable species.

Bryum argenteum Hedw. The silvery shining tufts make this little moss unmistakable. It is cosmopolitan.

Bryum blandum H. f. & W. A distinct and handsome species, to be found in wet places, sometimes submerged. It often has an attractive vinous red tint. The leaves are of soft texture, very obtuse or almost rounded, with a slender nerve failing shortly below the apex. Rodway gives the leaf border in his key as being absent, and in the description as being ill-defined, but his specimens show a border which, though somewhat sporadic, is often quite distinct, as it is in the New Zealand race.

Bryum laevigatum H. f. & W. Characterised by the robust habit, brown or greenish brown colour, and firm leaves imbricated evenly along the stem and sometimes distinctly bordered. It is common in New Zealand in high country and is usually hygrophilous, frequenting wet stones in rivers, &c. I understand that it is rare in Australia.

Bryum capillare Hedw. Syn. *Bryum torquescens* Br. & Schimp., *Bryum obconicum* Hornsch., *Bryum pyrothecium* Hpe. & C.M. The leaves here are lax and of soft texture, contracted and twisted when dry, often spirally twisted round the stem. They are bordered rather narrowly but distinctly, and the margin may be plane or recurved, entire or denticulate above. The nerve is far excurrent in a slender, flexuose, slightly denticulate arista. The seta is long, the capsule large and long, usually reddish, with the operculum red and shining. *B. torquescens* is a form with synoicous inflorescence, and there is no difference in habit though Rodway, in his key, separates them on that account. The leaf

texture in the present species is laxer and softer than it is in *B. pseudotriquetrum*, the cells are larger and the nerve further excurrent. Abnormal forms of *B. Billardieri* with a long excurrent nerve can be distinguished by the stouter habit, more comose stems and cells with firm walls.

Bryum pseudotriquetrum (Hedw.) Schwaegr. Syn. *Bryum bimum* Brid. The plants grow in tufts on wet earth, usually in swamps. The nerve is strong and only shortly excurrent, the leaves ovate-lanceolate or oblong-lanceolate, distinctly margined and shortly pointed. The cells are rather small above 40-60 μ long and 2-3 $\times$ 1. The capsule is large and brown, not reddish as in the last species. *B. bimum* has been separated on account of its synoicous inflorescence, *B. pseudotriquetrum* being dioicous, but the distinction tends to break down.

Bryum affine Lindb. Syn. *Bryum tasmanicum* Hpe., *Bryum creberrimum* Tayl. This species differs from the last in the narrower and more finely acuminate leaves, with the nerve further excurrent. The Studies (p. 207) states confidently that *B. tasmanicum* is identical with *B. affine*, so it is clear that the plant described by Rodway under the former name cannot possibly belong there, the peristome for one thing being wrongly described. The Studies (pp. 207, 213) states that the true *B. creberrimum* is the present species, and that Wilson had also mistakenly treated *B. obconicum* (i.e., *B. capillare*) as that. Rodway's specimens of *B. creberrimum* are referable to *B. capillare* too.

Bryum caespiticium Hedw. This species is in Rodway's collection under other names, including *B. caespiticioides* C.M., but does not appear in his work, though it is given as a Tasmanian moss in Flora Tasmaniae. His description of *B. caespiticioides* seems to fit the present species well enough, but the Musci assigns *B. caespiticioides* to the section *Doliolidium*, to which *B. dichotomum* &c. belong, so apparently there has been some confusion as to Müller's species. Müller himself, in Genera Muscorum Frondosum, treats it as of the *Caespitibryum* section, i.e., as akin to *B. caespiticium*. That species occurs in New Zealand and Australia, and has a wide distribution in the northern hemisphere. The leaves are rather small, 1-3 mm. long, crowded in comal tufts, oblong-lanceolate and narrowly acuminate, scarcely altered when dry, with the margins revolute and unbordered and the nerve far excurrent in a long arista. The cells are firm and rather narrow. The capsule is brown, clavate or oblong-pyriform, the peristome large and well developed, the spores 12-14 μ. It is a dioicous species, usually found in dry surroundings.

Bryum Billardieri Schwaegr. The following species recognised and described by Rodway cluster round *B. Billardieri*, which is the earliest publication, and with it form a most troublesome polymorphous group:— *B. breviramulosum* Hpe., *B. leptothecium* Tayl., *B. microrhodon* C.M., *B. rufescens* and *B. pyrothecium* Hpe. & CM. In addition to these, the Mascarene *B. truncorum* Brid. is treated in Hooker's Handbook and the Studies as being an Australasian moss. All the plants are characterised by the stout stems which are either comose, sometimes interruptedly so, or have the leaves more evenly arranged along them. The leaves when moist are either suberect or rosulately spreading, in shape oblong-ovate, oblong-obovate or oblong-spatulate, bordered either weakly or strongly with varying numbers of rows of narrow incrassate cells, toothed in

the upper part and with the margins recurved below. The nerve is excurrent in a short, recurved, slightly toothed point, but very occasionally this arista is greatly lengthened. The cells are firm-walled, rather small, rhomboid-hexagonal, the capsule clavate or narrowly oblong-pyriform, the inflorescence dioicous. The various species have been set up mostly on the degree of development of the border, combined with differences in habit and in the shape of the leaves. Extreme states in any of these directions are distinct enough, but there is no doubt that throughout Australasia there is a bewildering host of intermediate forms that resist systematic treatment. My inclination is to delimit *B. Billardieri* and *B. truncorum* by separating the plants into two groups where, in the case of the former species, the leaves are more or less evenly arranged round the stem, have a tendency to be ovate or oblong, and have the border narrow and often indistinct; and where, in the case of the latter species, the leaves are obovate or almost spathulate, often gathered together in comose rosulate heads, and are strongly and widely bordered. This is the treatment proposed by Dixon in the Studies. Mr. Willis informs me that the locality "Novo Belgio" given for the type collection of *B. Billardieri* must refer to Tasmania, and that the plant would have been collected near Hobart. The Studies, when describing this type specimen, mentions that the cells of the leaves of the sterile branches are larger than those in the leaves of the fertile branches. I have noticed the same thing in a specimen of *B. breviramulosum* in Rodway's collection, from Huon Road, and no doubt this variation is responsible for Rodway's statement that the cells in that species are smaller than in *B. Billardieri*, but that in some specimens they are rather large. The problem is made no easier by the fact that now and then a form is met with where the nerve is very far excurrent in an arista resembling that of *B. campylothecium*. From what I have seen of the New Zealand plants in the field I think that forms growing in arid surroundings tend to have the leaves densely imbricated into comose heads, and that forms growing in pasture have the stems more regularly foliate. Plants of the forest floor usually have the leaves green, comose and rosulate, spreading widely when moist. Some of the plants met with may therefore be conditioned, wholly or partly, by the environment. They are mesophytes and are seldom found in wet places.

Bryum crassum H. f. & W. In this rather small species the leaves are densely comose, interruptedly so on the longer stems, closely imbricated and little altered when dry. They are ovate-oblong and widely acute, practically unbordered and usually entire. The nerve is percurrent or shortly excurrent. The cells are small and strongly incrassate, with rounded angles. The capsule is brown, the neck short and rapidly narrowed to the seta. It is a very well marked species that occurs in New Zealand and has been collected recently at Canberra, Australia.

Bryum campylothecium Tayl. The affinity here is with *Bryum Billardieri* &c., of which it has the same firm areolation and size of cells, but there is no noticeable border, the marginal cells being almost undifferentiated. The margins are recurved, entire or slightly denticulate above. The nerve is excurrent in a very long arista. The leaves are closely imbricated into dense comose tufts, practically unaltered when dry. From

Rodway's description the capsule in the Tasmanian race is appreciably longer than it is in the New Zealand plant. His key would imply that the arista is normally short, though the description states that there is variability. I have not seen it anything but decidedly long.

Bryum chrysoneuron C.M. Syn. *Bryum erythrocarpoides* Hpe. & C.M. The above synonym is given in the Studies. Rodway states that the capsule there is brown, but it is a deep purple-red in *B. chrysoneuron* and this is an important diagnostic feature. It is narrowly clavate. The narrowly oblong-Panceolate leaves are of rather soft texture, unbordered and slightly denticulate above or entire. The nerve is golden-yellow or pink, excurrent in a cuspidate point. The seta is sometimes inordinately long in the New Zealand plant. The inflorescence is dioicous. The colouring of the nerve and capsule is the best guide to this species. It is closely related to the northern *B. erythrocarpum* Schwaegr., and as I have found in one of Rodway's specimens the crimson gemmae which are a specific character in the northern moss the relationship is shown to be closer still.

Bryum dichotomum Hedw. Syn.?? *Bryum ovicarpum* Broth., *Bryum cupulatum* C.M., *Bryum subcupulatum* C.M. I have seen too little of the species in the above synonymy to do more than suggest that they are probably conspecific with this. Rodway has reduced *B. pachytheca* to *B. dichotomum,* but they are usually kept separate owing to the capsule shape. In the present species the capsule has a short neck tapering to the seta, and more often than not there is a decided constriction below the mouth, making the capsule urceolate. In *B. pachytheca* the capsule base is enlarged and rugose, not at all tapered. In Rodway's key the vegetative characters are given as separating several species of this group, but in *B. dichotomum* there is such a wide range of variation in the shape of the leaf and the degree of excurrence of the nerve that no reliance can be placed on these differences.

Bryum pachytheca C.M. Syn. *Bryum gambierense* C.M., *Bryum argillicola* Broth.??. In *B. gambierense* the capsule is considerably longer than is usual in *B. pachytheca,* but it has the steep base of that in the present species and can only be treated as a form. Rodway's only specimen of *B. argillicola* has a single capsule which seems to be of *pachytheca* shape. *Bryum Sullivani* C.M. appears to be intermediate between *B. dichotomum* and *B. pachytheca* though perhaps nearer the latter. The shape of the capsule is really not typical of either.

Doubtful species.

Bryum rubiginosum H. f. & W. There is no specimen of this in the collection, but barren material is reported in Flora Tasmaniae. The Musci cites it as a Tasmanian moss of the section *Leucodontium,* but since no fertile plants have been seen I think that the record should be considered as doubtful in the meantime. No representative of the section has been reported in New Zealand.

Bryum microsporum Broth. Brotherus, in the Musci, includes this in a section of the *B. capillare* group. The specimen in Rodway's collection could be *B. capillare* itself, the leaf agreeing with that species; but the material is very scanty.

Bryum intermedium Brid. Dixon, in the Studies states that this species occurs in Tasmania, but he gives no particulars. Rodway mentions Colebrook as a locality and a named specimen in the herbarium is from there, but it cannot be this species because it has not got the synoicous inflorescence and large spores of *B. intermedium.* I should think that it is probably a form of *B. caespiticium.*

Bryum sp. There are two specimens in the collection from Meander River sub nom. *B. laevigatulum* Broth., and Rodway's description of that species seems to be intended to apply to the plants in question. The Studies suggests that *B. laevigatulum* is a form of *B. curvicollum* Mitt. with abnormally small spores, and from what I have seen of the original material, which is from New Zealand, I have little doubt that this view is correct. Rodway's specimens differ, however, in the distinctly bordered leaves, and may represent a new species. The spores are larger than in *B. laevigatulum.*

7. *Leptostomum* R. Br.

In his paper on this genus (*The Family Leptostomaceae,* the Bryologist, 54 : 217) Andrews arrives at the conclusion that the affinity of *Leptostomum* is with the Bryaceae, and that its most closely related genus is *Brachymenium,* where too the peristome is reduced, though not to the same extent as in *Leptostomum.* The leaf cells in this genus are short and isodiametrical, but I have found that in *L. macrocarpum* the lower rudimentary leaves sometimes have the areolation of typically bryoid nature, and Andrews agrees with me that this supports his view of the relationship. In the Studies *L. gracile* is united with *L. inclinans* which has page priority in publication. Neither *L. macrocarpum* (Hedw.) R. Br. nor *L. Menziesii* Hook. can at present be considered as a Tasmanian moss.

Footnote to Notes on Tasmanian Mosses from Rodway's Herbarium: IV.

Mnium longirostrum. I find that the specimen cited by Weymouth and Rodway as being this species consists of a mixture of *Pterygophyllum dentatum* (H. f. & W.) Mitt. and *Distichophyllum pulchellum* (H. f. & W.) Mitt. So far, therefore, as the material in Rodway's collection is concerned the record must be treated as incorrect.

Notes on Tasmanian Mosses from Rodway's Herbarium: V

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Family BARTRAMIACEAE

The leaf cells here tend to be short, pellucid and distinctly papillose, and the capsule is usually globose and furrowed. The following key to the genera may be helpful.

1. Peristome teeth conjoined above; operculum beaked	2. Conostomum
Peristome teeth not conjoined above	2
2. Leaves more or less plicate	3. Breutelia
Leaves not plicate	3
3. Capsule plicate; plants mostly peristomate	4
Capsule rugulose; plants gymnostomous	5. Bartramidula
4. Leaves quickly narrowed (except in *B. stricta*) from a widened or semi-sheathing base; stems without sub-floral whorls or branches	1. Bartramia
Stems with sub-floral whorls; leaves ovate-lanceolate	4. Philonotis

1. *Bartramia* Hedw.

Bartramia Halleriana Hedw. Syn. *B. norvegica* Lindb. This is the type species and it is widely distributed in the northern hemisphere. It is recognisable by the elongated straggling stems and numerous short, apparently lateral setae. *B. norvegica* is pre-Hedwigian and the name is invalid accordingly.

Bartramia papillata H. f. & W. Syn. *B. fragilis* Mitt. Although it is extremely variable as regards robustness and size, it is characterised in all its forms by the contrast between the smooth and hyaline areolation of the rectangular leaf-sheath and the much smaller cells of the subula, which are dense and obscure with low papillae. *B. fragilis* is considered by Rodway to be doubtfully distinct, and is reduced to synonymy in the Studies IV, pp. 226 (1926). The material so named in the collection (from Cradle Mountain) is certainly *B. papillata.*

Bartramia stricta Brid. This is much like forms of *B. papillata,* but is separable at once by the gradually tapered leaves from a broad but ill-defined base, the cells of which are firmer and shorter than they are there. It is a widely distributed species, and the relationship is with the New Zealand *B. alaris* Dix. & Sainsb., but the upper cells are much longer, 20-30 μ as against 10 μ.

Bartramia erecta (Hpe.) Broth. The Musci attributes *B. erecta* to Eastern Australia only, but Rodway cites it from Hobart localities and the collection contains specimens from there. Here too there is a strong resemblance to *B. papillata,* but the leaf-sheath is narrow and the capsule without peristome.

2. *Conostomum* Sw.

Apart from the fruiting characters mentioned in the key, the members of this genus are distinguishable by the quinquefariously arranged leaves which are of solid texture and difficult to soak out.

Conostomum australe Sw. This is a larger plant than the following. The stems are very densely matted together with tomentum, and the leaves are conspicuously arranged in five rows. The nerve is very wide and indistinct, excurrent in a smooth and hyaline arista.

Conostomum pusillum H. f. & W. The plants here are slender and the stems, though tomentose, are not densely matted together. The leaf arrangement is not so strongly marked as it is in *C. australe* and the nerve is narrower and clearly defined. Both species occur in New Zealand.

3. *Breutelia* Schimp.

The vegetative characters in the genus are robustness of habit, plication of the leaves and the presence in them of a basal marginal area of quadrate cells. The variable development of these characters has led to the creation of several badly defined and unsatisfactory species.

Breutelia pendula (Hook.) Mitt. Two of the species treated by Rodway as separable from this, i.e., *B. comosa* Mitt. and *B. divaricata* Mitt. are reduced to synonymy in the Studies. *B. Sieberi*, which is maintained there on account of less differentiated alar cells and longer upper ones, has since been shown by New Zealand material to be inconstant in these respects, and should be reduced accordingly. The plants are extremely variable, but in all its forms *B. pendula* is recognisable by the leaves which are plicate throughout, usually patulous, and from 2·5 mm. to 4 mm. long. I have seen Australian specimens where the alar group is so reduced as to be scarcely noticeable.

Breutelia affinis (Hook.) Mitt. Syn. *B. commutata* Jaeg. Differs from the last in the leaves being only plicate at the base, and in the more numerous and smaller alar cells with firmer walls and chlorophyllose contents. The stems and branches are cuspidate, the leaves erect and rigidly appressed when dry. The latter are not quite entire, as stated in Hooker's Handbook and the Studies, there being often, perhaps usually, some denticulation in the upper part of the margin which Rodway describes as serrulate. His opinion that *B. commutata* is conspecific is supported in the Studies.

Breutelia crassa H. f. & W. Rodway's collection contains a specimen named as this, which apparently is the plant referred to in his work. The collecting data are:—" November, 1910, Mt. Wellington, 3000 ft.". The material is barren and Rodway treats it as probably being only a robust condition of *B. comosa*, i.e., *B. pendula*. It is highly interesting because it is certainly identical with the New Zealand *B. elongata* (H. f. & W.) Mitt. This is a very robust and handsome moss, with flexuose branched stems and leaves which can attain 7 mm. They are markedly plicate, sharply denticulate, with very narrow linear cells that are papillose above, smooth below and more or less porose throughout. The alar group is conspicuous and the cells at the insertion are dark orange-brown. The

Studies describes the leaves as strongly falcate, but they are not invariably so: I have often seen them almost straight. The only other specimen in the collection under *B. crassa* differs in no way from *B. pendula*. This relationship between the giant forms of Breutelia that have been published as independent species seems to require investigation.

4. *Philonotis* Brid.

The leaves here are lanceolate and do not have the wide sheathing base of those of *Bartramia*. Their cells are more or less uniform throughout, mostly papillose at their upper ends. With the exception of *P. scabrifolia* the plants are markedly hygrophilous. The subfloral whorls are a good character, but the plants are often barren.

Philonotis scabrifolia H. f. & W. This is the only species of the subgenus *Catenularia* C.M. and in the absence of fruit the straggling stems, which are sometimes pinnately branched, have the appearance of a pleurocarpous moss and effectually conceal the true affinity. The colour is a characteristic glaucous or sage green, the leaves are very small with cells and nerve highly papillose. The male flowers are discoid and conspicuous, the capsule is large, and the subfloral whorl is strongly marked.

Philonotis tenuis (Tayl.) Jaeg. Syn. *P. fertilis* Mitt. This is a very variable species in size, recurvature of the leaf margin (it sometimes being plane), serrulation of same and papillosity of the cells. Rodway overstates the length of the leaf which he gives as 3 mm., whereas it seldom attains 2 mm. His view that *P. fertilis* is inseparable is no doubt correct, so far as can be judged from the gametophyte.

Philonotis australis (Mitt.) Jaeg. This New Zealand species is credited to Tasmania by Rodway in his Additions to the Tasmanian Flora (*Papers & Proc.*, &c., 31st December 1915). The specimen in his collection is evidently the plant there referred to. It is barren, and was collected by Weymouth at St. Mary's Pass and determined by Brotherus. It is a difficult plant in that the leaf shape and habit are as in small forms of *P. australis*, the leaves being shortly pointed and often slightly falcate, whilst the recurved leaf margin and short cells are characteristic of *P. tenuis*. I am inclinded to think, therefore, that in the meantime *P. australis* should be treated as a doubtful Tasmanian species.

Philonotis rigens Broth. There seems to be no moss so-named in the collection, and Brotherus does not mention it in the Musci. From Rodway's account it might perhaps be a form of *P. tenuis* with plane-margined leaves.

5. *Bartramidula* Schimp.

Plants very slender with a creeping habit and small lanceolate leaves. Capsule gymnostomous and usually either smooth or rugulose, not furrowed.

Bartramidula pusilla (H. f. & W.) Schimp. This is a tiny moss with straggling stems and julaceous, slightly curved, branches. The leaves are only about 0·5 mm. long, densely imbricated and broadly lanceolate, with the margins bluntly dentate above. In Rodway's var. *Weymouthii* the capsule is tuberose at the base, but to judge from what I have seen in the collection this character may not be quite constant. The spores seen were very large, up to 80 μ in diameter, and sharply papillose. The variety has been reported from Victoria and West Australia, and this is the only known extension of the distribution. As has been already mentioned in Part 2 of these Notes, Rodway (in Additions to the Tasmanian Flora) mistakenly gives the inflorescence as dioicous, he having confused the present plant with the gemmiferous form of *Pleuridium nervosum*. The Flora Tasmaniae states that the inflorescence is synoicous and monoicous. The male buds that I have seen were on a stem or branch that might or might not have been connected with a fertile one.

Family SPLACHNACEAE

Plants with short stems, mostly growing on animal droppings. Leaves wide and soft, nerved, with large, lax, smooth and more or less hexagonal cells. Capsule erect and symmetrical, with a conspicuous apophysis and small convex operculum. In a valuable and interesting paper ("The chequered story of two Tasmanian Mosses"; *Victorian Naturalist*, Vol. 67, June 1950, p. 30) J. H. Willis has transferred to *Tayloria*, as being the most acceptable genus, the two species of *Tetraplodon* appearing in Rodway's work, with the result that only the one genus of this family is, rather tentatively, recognised by him for the local flora.

Key to the Species of Tayloria

1. Apophysis much wider than the capsule	2
Apophysis not wider than the capsule	3
2. Nerve excurrent, leaf margin entire	1. tasmanica
Nerve failing below apex; leaf margin irregularly toothed	2. Gunnii
3. Leaf margin sharply toothed above; nerve failing	3. calophylla
Leaf margin entire or slightly and bluntly toothed; nerve excurrent in the upper leaves	4. octoblepharis

1. *Tayloria tasmanica* (Hampe) Broth. The apophysis here, though distinctly wider than the capsule, is much smaller than in *T. Gunnii*. Willis (loc. cit.) points out that the sporophore has a banded appearance, being dark brown above and whitish below.

2. *Tayloria Gunnii* (W. Wilson in Hook.) Willis; Syn. *T. obtusissima* Broth. ? This is distinguishable from the preceding by the short nerve and the very large discoid apophysis. Willis's apt comparison of the appearance of the capsule and apophysis mentions a "tall Welsh hat". The only specimen of *T. obtusissima* in the collection appears to conform vegetatively to the present species, and it seems from Rodway's account that no fruit has been seen. In that case I think that it must be considered as a somewhat doubtful species.

3. *Tayloria calophylla* (C.M.) Mitt. A robust plant clearly distinguishable by the sharp serrations in the upper part of the lamina and by the failing nerve. It is a New Zealand moss which I have only seen

from the northern part of the North Island, and its occurrence in Tasmania is rather uncertain. Rodway states that the only specimen in the collections is from New Zealand, but Dixon, in the Studies, expresses belief in the wider distribution, though he does not give particulars. The Musci mentions it as a Tasmanian moss.

4. *Tayloria octoblepharis* (Hook.) Mitt. This has a wide Australian and subantarctic distribution. It is a smaller plant than *T. calophylla* and, in addition to the vegetative characters, differs in the peristome teeth being reflexed on to the capsule wall when dry instead of being slightly incurved, as there.

Family FUNARIACEAE

Vegetatively the plants here are as in Splachnaceae, but the capsule is usually globose or pyriform and may be erect or cernuous. There is no apophysis, and the peristome, when present, is single or double. The genus *Gigaspermum* which is included here by Rodway, is, with three others, placed by Brotherus in the separate family Gigaspermaceae. The remaining genera, *Physcomitrium* and *Funaria,* have a similar habit and areolation, but in the former the calyptra is mitriform and lobed at the base and the capsule is gymnostomous, whereas in *Funaria* the calyptra is cucullate and the capsule is often peristomate.

Physcomitrium conicum Mitt.

A well marked species, allied to the European *P. pyriforme.* The leaves have the marginal cells narrower and longer than the inner ones, and form blunt serrulations by projection of their ends. The nerve fails in the apex. The capsule is pyriform or turbinate, with a wide mouth. The plant, in New Zealand at any rate, grows in quantity on the muddy banks of streams and drains.

Physcomitrium laxum H. f. & W. Rodway considers this to be a shade form of *P. conicum,* and gives the locality as the Upper Meander River. The only specimen I have seen is in imperfect fruiting condition and purports to have been collected by Rodway on Mt. Wellington Plateau. The leaf margin is not serrulate and the lamina cells run out from the nerve in regular divergent rows, as in *Tayloria purpurascens* (H. f. & W.) Broth., a New Zealand and subantarctic moss. I am unable to give an opinion as to the standing of *P. laxum.*

Funaria Schreb.

Subgeneric rank only is recognised for *Entosthodon,* where the capsule is erect and the peristome is usually lacking, and *Eufunaria,* where a curved and asymmetrical capsule is combined with a more or less perfect peristome. *F. glabra, F. hygrometrica* and *F. cuspidata* belong to the latter subgenus and the other Tasmanian species to the former. It is noteworthy that in this genus the processes, when present, are placed opposite to the teeth and do not alternate with them as in a normal double peristome. All the Tasmanian species occur in New Zealand. *Funaria* is one of the few moss genera where hybridism has been established.

Key to the Species

1. Capsule gymnostomous	2
Capsule peristomate	3
2. Leaves lanceolate-subulate; seta much longer than the capsule and neck	2. producta
Leaves ovate or obovate; seta much shorter than the capsule and neck	1. apophysata
3. Capsule striate	6. hygrometrica
Capsule smooth	4
4. Capsule asymmetrical and curved; peristome large and persistent.	5. glabra
Capsule erect and symmetrical; peristome small and fragile	5
5. Nerve excurrent; imperfect inner peristome present	3. cuspidata
Nerve failing below apex; peristome single	4. gracilis

1. *Funaria apophysata* (Tayl.) Broth.

There is a link here with the Splachnaceae in the very long neck which quite equals the capsule, the two together usually exceeding the length of the seta. The Tasmanian plant has the nerve far excurrent in the topmost leaves, but it fails below the apex in the New Zealand race.

2. *Funaria producta* (Mitt.) Broth.

This is easily recognised by the narrow ovate-lanceolate leaves, narrow cells and pyriform gymnostomous capsule. It formerly ranked as a Tasmanian endemic, but it has been found in the North Island of New Zealand, and I share Mr. Willis's opinion that the Victorian *F. perpusilla* Broth. is conspecific.

3. *Funaria cuspidata* H. f. & W.

Rodway's note on this species is that it is continuous with *F. gracilis*, and there is much to be said for that view. A vague and rudimentary inner peristome is present here and lacking there, but otherwise the fruiting characters entirely agree. In *F. cuspidata* the leaves are erecto-patent when moist and the nerve is mostly far excurrent, whereas in *F. gracilis* the leaves are erect and the nerve vanishes below the apex. In the Studies (pg. 193) Dixon comments that no clear line can be drawn to separate *Entosthodon* and *Funaria*. The truth of this statement is illustrated by the fact that *Brotherus*, treating them as subgenera, has assigned *F. cuspidata* to *Eufunaria* and *F. gracilis* to *Entosthodon*.

4. *Funaria gracilis* H. f. & W.

See note to *F. cuspidata*.

5. *Funaria glabra* Tayl. Syn. *F. crispula* H. f. & W.; *F. tasmanica* Hpe.?

A very distinct plant in the strongly arcuate smooth capsule, with its wide mouth and well-developed double peristome. The leaf is distinctly bordered by one or two rows of narrow, often yellowish cells, and its margin is bluntly serrulate above by projection of the cell apices. *F. crispula* is, from Rodway's description and specimen, merely a form of *F. glabra*, and this was his recorded opinion. The only specimen of *F. tasmanica* in the collection seems to agree well with the present species, but I have not seen type material.

6. *Funaria hygrometrica* Hedw.

This is one of the best known mosses in the world, and when in normal fruit it is unmistakable. The long seta is arcuate when young and the capsule is obliquely pyriform, gibbous, sulcate when dry, and incurved at the mouth. The outer teeth of the peristome are spirally arranged and united at their apices in a small disc. The deeply concave leaves are, according to Rodway's description of the Tasmanian plant, elliptic and apiculate. The margin is plane and entire, and the nerve thin and percurrent. The New Zealand plant often has the leaves more gradually pointed than in European forms.

Family GIGASPERMACEAE

This family contains four small genera of Funarioid affinity where the plants have creeping rhizomatous stems with erect and crowded fertile branches. The areolation is lax, the capsule gymnostomous and almost immersed, with very large spores. In the genus *Gigaspermum*, to which the Australian moss belongs, the leaves are nerveless and the capsule is immersed.

Gigaspermum repens (Hook.) Lindb.

In this curious little moss the leaves are imbricated, nearly orbicular, shortly cuspidate. The perichaetial bracts are much larger and slenderly acuminate. They are conspicuous through their size and the hyaline scariose tissue which gives them a whitish appearance. The widely urceolate capsule is almost sessile and is more or less concealed by the bracts. The spores are very large. The Musci gives them as reaching 70 μ in the genus, and this figure is repeated in the Studies in the description of the present species, but I have seen them far larger, nearly 200 μ in a Tasmanian specimen. I have not seen *G. tumidum* (Mitt.) which is given in the *Musci* as endemic in Tasmania, but as all the species are said there to be very closely related, I have little doubt that it is conspecific.

Notes on Tasmanian Mosses from Rodway's Herbarium: VI

By

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The pleurocarpous mosses are included by Rodway in ten families or subfamilies, the great majority of them being grouped together under Hypnaceae and Neckeraceae. Modern treatment would recognise more than double that number of families and in this respect, as well as in allocation of genera according to their true affinities, Rodway's work is out of touch with modern ideas. As, therefore, it is not practicable for me to adhere to his arrangement and at the same time make the necessary modifications, I propose, from now on, to take the families in their order as appearing in Dixon's Classification of Mosses (*Manual of Bryology*, The Hague, Chap. 14), but without grouping them into orders and sub-orders, as shown there.

Family PLEUROPHASCACEAE

The curious moss *Pleurophascum grandiglobum* Lindb., which until recently had ranked as a Tasmanian endemic, is now recognised as constituting a monotypic family rather distantly related to the Dicnemonaceae. A varietal form has lately been found in the Westland District of New Zealand. It deviates from the typical plant mainly in having the leaves entirely without a flagellate apiculus, but it should be mentioned that in Tasmanian material I have found plants in which the apiculus was lacking in some of the leaves. The variety, therefore, is probably not very sharply defined. The moss is recognisable by the long seta and large, yellow, globose capsule. Its presence in New Zealand is as interesting a link between the two floras as is the presence in Tasmania of *Ephemeropsis trentepohlioides* and *Hampeella alaris*.

Family HYPNODENDRACEAE

The plants are robust and handsome, with dendroid secondary stems from a creeping primary stem. The branches are often clustered into a whorl at the apex of the stipe, and the appearance then is that of a miniature tree-fern. The leaves are ovate-acuminate, toothed and singly nerved; the cells narrowly linear. The setae are long, emanating from the base of the branches and often numerous. The only Tasmanian genera are *Hypnodendron* and *Mniodendron*, and in the studies the view is advanced that they are not satisfactorily distinguishable.

Mniodendron comosum (La. Bill.) Lindb. Syn. *Mniodendron comatum* (C.M.) Lindb.; *M. Sieberi* C.M.

The stipes are densely tomentose and with a terminal whorl of branches which may be stout and straight or slender and curved. The branch leaves have their margins variably bistratose and serrate. The nerve is excurrent and of variable width. Rodway's doubt as to the independence of the species in the synonymy seems to be justified, and I believe that in Tasmania, as in New Zealand, only the one variable species is involved.

Hypnodendron arcuatum (Hedw.) Mitt. Syn. *H. spininervium* Hook.; *H. Archeri* Mitt.

Distinguishable from the last species by the naked stipes which usually end in a pinnate complanate frond instead of a whorl of branches. The branch leaves are ovate, with the margins unthickened and serrate, and with the percurrent nerve toothed at the back above. The cells are usually papillose on the dorsal face. In New Zealand the plants are often found on the banks of densely shaded watercourses in the bush. They are green and glossy when dry.

Family RHACOPILACEAE

The genus *Rhacopilum* is included by Rodway in his family Lophidiaceae which corresponds with the modern Hypopterygiaceae. *Rhacopilum* has no real affinity with that group, because the small differentiated median leaves are placed in dorsal rows, whereas in the family mentioned they are true amphigastria and as such are ventrally arranged. The two species given by Rodway for Tasmania, *R. strumiferum* and *R. cristatum*, occur also in New Zealand. They have been kept apart by the robuster habit, stouter seta and more hairy calyptra in *R. strumiferum*, but these characters, as exhibited in New Zealand plants, seem to me to be inconstant and uncertain, and this is evidently the view taken in the Studies.

Family CRYPHAEACEAE

The Studies does not recognise the genus *Dendrocryphaea* as distinct from *Cryphaea*, so if that view is adopted there is only the one genus represented in Tasmania, as in New Zealand. In view of its Australian and New Zealand distribution the species *C. dilatata* might well be expected to be found in Tasmania.

Cryphaea tenella (Schwaegr.) Hornsch. Syn. *C. parvula* Mitt.

This is a slender corticolous moss with very thin, irregularly branched secondary stems, small long-acuminate leaves which are closely appressed when dry, numerous immersed capsules and gemmiform male buds. I have found the leaves and capsules to be usually shorter than 1·2 mm. and 2 mm. respectively as given by Rodway. The Studies treats *C. parvula* as a synonym.

Cryphaea tasmanica Mitt. Differs from the last in the aquatic rupestral habit, the robust dull-green stems which are sparingly branched except for the crowded perichaetial branches, and the orbicular-ovate leaves. The perichaetia are usually homomallous in New Zealand plants.

Family HEDWIGIACEAE

The plants here are robust and rigid, with irregularly branched stems. The leaves are coriaceous, imbricated and nerveless, with papillose cells. Rodway maintains *Hedwigidium* as a separate genus, but it is usually merged in *Hedwigia*. *Rhacocarpus* is the only other Tasmanian genus.

Hedwigia P. Beauv.

Differs from *Rhacocarpus* in the unbordered leaves, without differentiated alar cells, and the immersed capsules. Both of the Tasmanian species have a wide boreal and austral distribution.

Hedwigia ciliata (Hedw.) P. Beauv. Syn. *H. albicans* (Web.) Lindb. Grows in loose hoary tufts on non-calcareous rock, and outwardly resembles *Grimmia laevigata* owing to the diaphanous leaf apex. The leaf margin is recurved below and the cells are strongly papillose. The long flexuose cilia of the perichaetial leaves are very characteristic.

Hedwigia integrifolia P. Beauv. Syn. *Hedwigidium imberbe* (Sm.) Bry. eur. There is a strong outward resemblance here to the last species, but the leaves lack the hair-point and have the margins revolute to near the apex. The cells are only slightly papillose and the perichaetial bracts are not ciliate. Curiously enough the two species have been found growing in close association in New Zealand, New South Wales and Equatorial Africa.

Rhacocarpus Lindb. The genus belongs to the subfamily Rhacocarpoideae and there is no obvious structural affinity with *Hedwigia*.

Rhacocarpus Humboldtii (Hook.) Lindb. Syn. *R. australis* (Hpe.) Par.

This is a well-marked rupestral moss which could not be mistaken for anything else. The leaves are rigid and harsh, nerveless, bordered for a great part of their length with long narrow cells, and produced at the apex into a long flexuose apiculus. The areolation is obscure with fine and dense papillae, with the exception of the orange-red basal cells. The hair-point is similarly tinted. The capsule is far exserted on a seta of variable length. My study of the New Zealand plant has convinced me that the separating characters of *R. australis* are inconstant, and that the Australasian plant should be treated as a regional race of the widely distributed *R. Humboldtii*.

Family PTYCHOMNIACEAE

This family was created by Fleischer to accommodate a group of mosses having in common a plicate capsule and well developed peristome, combined with leaves that are nerveless or nearly so. Two genera are given by Rodway for Tasmania, i.e., *Ptychomnion* and *Glyphothecium*, and I consider that a third, *Hampeella*, is represented by a moss which was published on New Zealand material as a *Glyphothecium* after having been previously discovered in Tasmania by Weymouth, and wrongly determined by Brotherus as *Catagonium politum*. As is pointed out in the Studies (p. 370), the correct spelling of *Glyphothecium* is as given here, and it should be noted that Rodway's account of the genus is incorrect in stating that the capsule is smooth, it being distinctly ribbed when dry.

Ptychomnion aciculare (Brid.) Mitt.

A very handsome moss with rigid flexuose stems, reddish or black tinted, and squarrosely spreading leaves. The tall dark seta and long strongly ribbed capsule are distinctive fruiting characters.

Glyphothecium sciuroides (Hook.) Hampe.

This moss is recognisable in the field by the yellow and rather rigidly spreading leaves. The branches often curve upwards and the appearance is then very striking. Short axillary brood-filaments are often produced in quantity towards the ends of the branches, and paraphyllia are numerous on the stems. The distribution is East Indian as well as Australasian.

Hampeella alaris (Dix. & Sainsb.) Sainsb.

A remarkable moss which is known only from Tasmania and New Zealand. It is difficult to fit comfortably into any of the genera of the family, but I have given reasons for preferring *Hampeella* to *Glyphothecium* for it (*The genus Hampeella C.M. in New Zealand;* Rev. Bry. et Lich. 40 : 94). The Tasmanian plant, which was barren, was collected on Myrtle branches at Blue Tier, Pioneer Track. It is loosely tufted, yellowish and glossy, with finely cuspidate branches and mostly appressed leaves. The latter are remarkable for their polymorphism, the lower ones being oblong-oval or cymbiform, with recurved tips, the upper ones being much narrower, less concave, bluntly pointed. There are long brood-filaments amongst the upper leaves. The leaf cells at the angles are orange or purple and form small but conspicuous auricles. Even without its strongly 8-ribbed capsule it is amply distinguishable from any other Tasmanian moss.

Family LEPYRODONTACEAE

The family is monotypic and the sole genus, *Lepyrodon,* is represented in Australasia and South America. The only Tasmanian species, *L. lagurus* (Hook.) Mitt., has a similar distribution. It is a distinct plant in its close glossy mats which grow on logs, &c. The stems are densely matted together with dark tomentum and the leaves are tightly imbricated, hair-pointed and very faintly nerved. The oblong erect capsule is borne on a seta which, at any rate in the New Zealand race, is often fragile. Rodway's collection contains several gatherings from Mt. Wellington, but no other Tasmanian localities are given. The New Zealand *L. australis* Hpe., which differs in its strongly plicate leaves, should be looked for in Tasmania.

Family PTEROBRYACEAE

A large tropical and subtropical family. The two Tasmanian genera are *Trachyloma* and *Rhabdodontium.*

Trachyloma planifolium (Hedw.) Brid.

This is a frondose, flattened, corticolous moss with pale-green, often whitish scariose leaves. In the species the branches are frequently denuded of leaves at the apex and clothed there with brown brood-filaments,

but Rodway does not mention them, and I did not find them in the only specimen I saw from the collection. These filaments, which constitute a device for asexual reproduction, are a frequent and conspicuous feature in the New Zealand plant.

Rhabdodontium Buftoni (Broth. & Geh.) Broth.

I have only seen a barren scrap of this interesting and monotypic Tasmanian endemic. The Musci supplements Rodway's account and adds an illustration. The capsule is described as completely immersed, the peristome teeth broadly lanceolate, with a rudimentary inner peristome. Vegetatively it is distinct in the long flexuose stems, short branches, and imbricated nerveless leaves which are ovate and shortly acuminate, with narrowly linear cells.

Family METEORIACEAE

In this family the plants are mostly corticolous, with long, tangled, more or less pendulous stems. Two genera, *Weymouthia* and *Papillaria*, are represented in Tasmania. In the former the stems are soft and glossy, often forming large pendulous patches on the bark of trees, the leaves being smooth and of thin texture; whilst in *Papillaria* the habit is more rigid and the leaves are firmer and densely papillose.

Weymouthia cochlearifolia (Schwaegr.) Dixon. Syn. *W. Billardieri* Broth.; *Lembophyllum cochlearifolium* Lindb.

Variations here in the length and nature of the branches, which are well described by Rodway, have led to confusion in the systematic treatment which even went so far as to assign the species to two different families. The Studies keeps up the form with a short seta and turgid capsule as a var. *Billardieri*, but this is done with doubt and my own view is that the variety is too weak to be sustained. *W. cochlearifolia* is distinguishable from *W. mollis* by the more robust habit, the large suborbicular cochleariform leaves which are usually more crowded, and the porose leaf cells.

Weymouthia mollis (Hedw.) Broth. The habit here is normally pendulous and the leaf texture very soft. The leaves are rather distant, oblong, rounded, cucullate at the apex. The Studies mentions difficulties in distinguishing some forms from *Lembophyllum clandestinum*, but I think that the comparatively short (25 μ or less) cells in the upper part of the leaf in the latter plant will always suffice to separate the present species, where the same cells are 40-70 μ long and narrowly vermicular.

Papillaria C.M.

In these frequently pendulous mosses, which form intricate mats on bark, the leaves are lanceolate from an auricled base and the cells are papillose. Fruit is so rare in the genus that the specific characters are almost entirely vegetative. These are often anything but easy to apply because the plants are very variable.

KEY TO THE SPECIES

1. Plants soft and slender; leaf margin unbordered; cells distinct, with few papillae	4. nitens
Plants rigid; leaf margin usually bordered with pale cells; upper cells obscure and densely papillose	2
2. Leaf margin widely bordered in the auricles, narrowly elsewhere; ultimate leaves usually apically forked	3. flavo-limbata
Border narrow throughout; leaves not apically forked	3
3. Leaves plicate when dry, nerve stout and prominent at back	1. crocea
Leaves convex and smooth at back, with apex divergent	2. flexicaulis

1. *Papillaria crocea* (Hpe.) Jaeg. Syn. *P. kermadecensis* C.M.

The dry plant is recognisable by the plication of the leaves which are furrowed at the back on each side of the prominent nerve. Rodway gives the habit as slender, but it is variable, sometimes quite robust. The border of pale smooth cells is variably developed, as is the denticulation of the auricles which is occasionally lacking. The Studies mentions forms where the leaves are not or scarcely plicate. These variations are not surprising in view of the wide East Indian and Pacific distribution, if Dixon's opinion that only one species is involved is correct, a conclusion with which I quite agree so far as my knowledge of the plants extends.

2. *Papillaria flexicaulis* (Tayl.) Jaeg. Syn. *P. filipendula* (H. f. & W.) Jaeg.

I share Rodway's opinion that these are conspecific, but *P. flexicaulis* has priority. The leaves are closely imbricated, convex and smooth at the back, with the apices divergent. The nerve is shorter than in *P. crocea* and the auricles are perhaps usually, but certainly not always, entire. I have never been able to see in *P. filipendula* anything more than a slender form of the present species with finely drawn out leaves.

3. *Papillaria flavo-limbata* (C.M. & Hpe.) Jaeg.

This plant is well marked in its robust habit, orange or yellow colour and turgid branches. The leaves are large, erect or suberect when dry and rather rigidly spaced. They are not plicate and have a very broadly auricled base. The border is wide and conspicuous below. The ultimate leaves of the slenderer branches and filiform prolongations usually end in a piliform flexuose point which is forked at its apex with 2-3 very short branchlets. Forms with greatly attenuated branches are very common.

4. *Papillaria nitens* (H. f. & W.) Sainsb.

The Studies discusses the New Zealand *Meteorium nitens* H. f. & W., which was set up on scanty barren material in Wilson's herbarium at the British Museum, but does not mention the possibility that it might be conspecific with the Australian and New Zealand *Papillaria nitidiuscula* Broth. which is described on the preceding page. My inquiries at the Museum convinced me of the identity of the plants and I proposed the change of genus accordingly (*Critical New Zealand Mosses;* Rev. Bry. et Lich., 21 : 221). It must, however, be conceded that the two genera are weakly defined. A Tasmanian specimen, from East Tamar, is in

Rodway's collection sub nom. *Papillaria intricata* (Mitt.) Jaeg., a Samoan moss which Dixon considers to be quite different. *P. nitens* is distinguishable at once from the other Tasmanian species by the fewness of the leaf papillae, 1-3 only to a cell, which gives the upper areolation an appearance quite different from that of the opaque tissue of the other species where the cells are densely papillose. The branches, other than the earlier ones, are pendulous and slender and the leaves are laxly set, with the broad auricled base arched out from the stem and contracted to a subula which is erect but not appressed. The nerve is short and faint.

Family NECKERACEAE

Modern treatment limits this family to a large group of mosses of robust habit, with flattened secondary stems and complanate shortly pointed leaves which are sometimes transversely undulate. The nerve is either single, or double and faint, the cells smooth and the capsule immersed or exserted. The genera established as Tasmanian are *Neckera* and *Thamnium*. A third, *Homalia*, appears to be doubtful, Rodway stating that the New Zealand *H. falcifolia* is recorded from Tasmania but that there are no Tasmanian specimens in any of the collections. The Studies gives it as indigenous in Tasmania but my inquiry at Kew has not convinced me that this is correct.

Neckera Hedw.

Neckera pennata Hedw. Syn. *N. hymenodonta* C.M. The Australasian *N. hymenodonta* has been kept apart from this widely distributed boreal species by the longer processes of the endostome, but the peristome in the southern plant is so variable in this respect that I do not consider that the separation is justified. In Rodway's account of the Tasmanian moss the processes are stated to be very long, and in one of his specimens they are three-quarters the length of the teeth; but in the same peristome other processes were less than half that height, so I do not think that the account can be accepted without qualification. The plant is easily recognised by the flattened stems and branches, the strongly undulate nerveless leaves and the numerous capsules which are immersed in long bracts.

Thamnium Schimp.

In this genus the leaves are not undulate, the single nerve is well developed and the capsule is exserted on a fairly long seta. It is remarkable that the New Zealand and Australian *T. pandum* (H. f. & W.) Jaeg. has not been recorded from Tasmania because it is, at any rate in New Zealand, quite a common aquatic or semi-aquatic moss. In my opinion the East Indian *T. latifolium* is conspecific, as is also the Australasian and Pacific *T. eflagellare*. *T. pumilum*, which appears to be more plentiful in Tasmania than in New Zealand, grows on stones in streams. Its habit is very slender, with flattened stems and small leaves (0·75 mm.) long. The nerve usually fails about midleaf but is sometimes lengthened, though always ending well below the apex.

Family ECHINODIACEAE

The only genus, *Echinodium* Jur., has a most intriguing discontinuous distribution. It is confined to Madeira and the Azores in the northern hemisphere and Australasia and some Pacific islands in the southern.

Echinodium hispidum (H. f. & W.) Jaeg.

Rodway's description of the habit as flaccid does not hold good in the typical form, and indeed contradicts the specific name. Nevertheless, although the plants are usually robust and rigid, the species is very variable indeed, and slender and delicate forms occur which, whilst showing no structural differences, are very dissimilar in outward appearance. The dark green colour, rigidly imbricated and long acuminate leaves, and the nerve far excurrent in a rigid arista are strong characters. *E. hispidum* is often aquatic but is by no means constantly hygrophilous.

Family LEMBOPHYLLACEAE

The characters in this family are well marked, the stems being robust and woody, often dendroid. The leaves are concave, faintly nerved or nerveless, with rather long cells except at the angles, where they are small, dark, and sometimes inflated. The seta is elongated and the peristome double, with processes and cilia well developed. *Lembophyllum* and *Camptochaete* are the two Tasmanian genera.

Lembophyllum Lindb.

Dixon, in the Studies, treats *Lembophyllum cochlearifolium* as a synonym of *Weymouthia cochlearifolia,* and in my opinion *L. divulsum* is no more than a varietal form of *L. clandestinum.*

Lembophyllum clandestinum (H. f. & W.) Lindb. The plants are robust with stout and woody stems that are irregularly pinnately branched, but not dendroid. The leaves are suborbicular and cochleariform, very closely imbricated so as to make the branches julaceous. The nerve is lacking or faint, and the cells are narrowly oval except at the angles, where they are subquadrate or rounded and form small and dark auricles. In my variety *divulsum* (see *Synonyms of some New Zealand Mosses;* Rev. Bry. et Lich.; 17 : 83), the upper cells are shorter, but there is no very sharp dividing line, and certainly no constant correlation between a more distinct nerve and punctiform upper cells, the two characters on which *L. divulsum* was founded.

Camptochaete Reichdt.

The dendroid, rigid, woody stems distinguish the plants, except in *C. gracilis* the generic position of which is scarcely settled. There is a tendency to produce flattened and elongate forms in which the dendroid habit is less pronounced. *C. deflexa* Wils. is one of these and cannot be considered as having specific standing.

Camptochaete arbuscula (Hook.) Jaeg. The stem leaves are closely imbricated, wrinkled and baggy, shortly acute. In *C. ramulosa* (Mitt.) Jaeg., which is closely related, they are smooth, very rigidly imbricated and with longer points. The seta is usually longer in the latter species, 1-5 cm. as against less than 1 cm.

Camptochaete gracilis (H. f. & W.) Par.; Syn. *C. tasmanica* Broth. A small, slender, soft moss which is usually found on wet rock or stones margining creeks. The stems are irregularly branched, not dendroid, and the leaves are imbricated and often secund. Their dorsal surface is sometimes papillose, and this occurs in *C. tasmanica* which is a form with loose habit and spreading leaves. It is not mentioned in the Musci.

Camptochaete vaga (Hornsch.) Broth. An Australian species which the Musci gives for Tasmania, but which is neither mentioned by Rodway nor in his herbarium. It is characterised by a combination of the dendroid habit in the genus with the suborbicular and cochleariform leaves of *Lembophyllum.* They are shortly and abruptly mucronate.

A New Turbellarian parasitic in the Sea-star, *Coscinasterias calamaria* (Gray)

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(with 6 text figures and 2 plates)

Abstract

A description of a new Turbellarian found encysted in the connective tissue of the tube-feet of the Sea-star, *Coscinasterias calamaria* (Gray) is given. The Turbellarian is devoid of a mouth, pharynx, intestine and certain other organs. It appears to be an aberrant rhabdocoel and is named *Acholades asteris* gen. et sp. nov. A new family, Acholadidae, is erected for its reception.

Introduction

Although a number of Turbellarians have been recorded as endoparasites of Holothuroidea and Echinoidea, only one seems to have been discovered in a member of the Asteroidea. It was found in several species of *Pteraster* occurring in the Gulf of Kola, Northern Russia, and was described under the name of *Pterastericola fedotovi* by Beklemicheff (1916, p. 34).

The species described in the present paper is an endoparasite of the large eleven-rayed sea-star, *Coscinasterias calamaria* (Gray), which is common in D'Entrecasteaux Channel and at other localities on the East Coast of Tasmania. The parasite becomes encysted in the connective tissue of the tube-feet of the sea-star. As so often happens in cases of parasitism the infecting organism exhibits marked degeneration and loss of structures which are normally present. Thus, mouth, pharynx intestine and certain other organs are lacking. However, there are sufficient characters to justify regarding the parasite as an aberrant rhabdocoel. It is named *Acholades asteris* gen. et sp. nov. A new family is established for its reception.

Description

Order: NEOOPHORA

Sub-order: Neorhabdocoela

Family: Acholadidae, nov.

Definition of Family: Neorhabdocoela with body epithelium completely cilated. Without mouth, pharynx and intestine. Vitellaria strongly developed and separate from germaria, which are paired and lobed. Testes fully developed only in young stages. Without male copulatory organ and ejaculatory duct. Genital aperture and main nerve centre posterior.

Genus: *Acholades* nov.

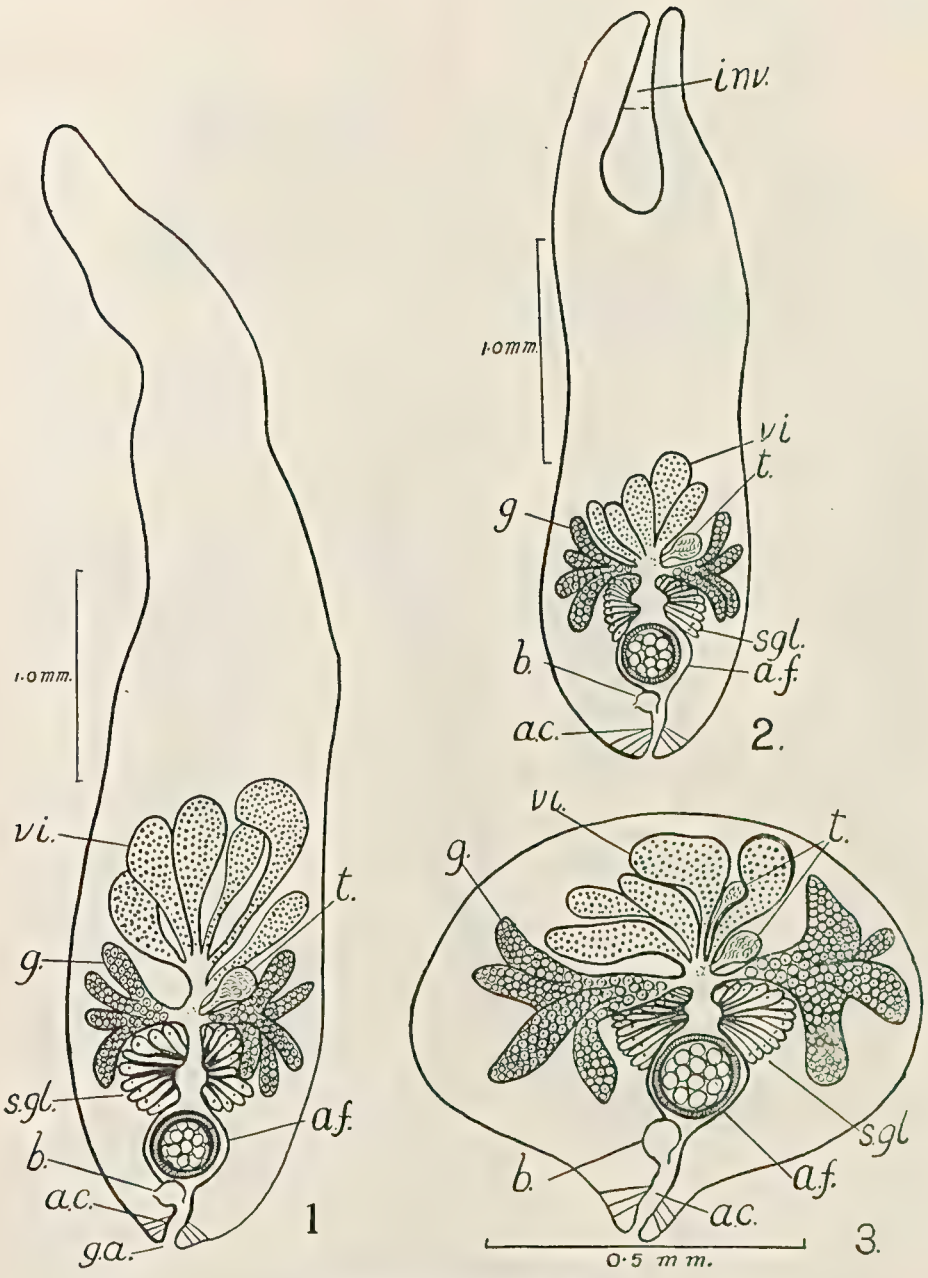
Definition of genus: As for family
Type of genus: *Acholades asteris* sp. nov.

Acholades asteris sp. nov.

(TEXT FIGURES 1-6. PLATES I AND II)

External features and cysts: The cysts formed by the Turbellarian occur in the connective tissue between the ectoderm and the muscle layer of the tube-foot. No separate cyst wall is laid down, the parasite being merely surrounded by the connective tissue, which does not exhibit any marked alteration. Usually only one cyst is present but occasionally two or three occur in one and the same tube-foot. In most cases they are found near the base and have the form of conspicuous yellowish pear-shaped or spindle-shaped structures, which project outwards and downwards from the side of the tube-foot. Not so conspicuous, however, are small ovoid cysts, which are embedded in the connective tissue of the sucker-disk and which produce only a slight bulging of the margin of the disk (Plate I, figs. 1-4). The spindle-shaped cysts measure up to about 5·0 mm. in length and 1·37 mm. in diameter at the widest part. They usually open to the exterior at the distal or lower end. The small ovoid cysts in the sucker-disk, however, are wider than long. They measure 0·52-0·69 mm. in length and 0·75-0·98 mm. in width. They open to the exterior on the under-surface of the disk. In no case does any communication exist between the cavity of the cyst and the cavity of the tube-foot.

In the long spindle-shaped cysts the animal rests with the end bearing the genital aperture downwards and near the opening of the cyst. The shape of the Turbellarian more or less conforms to the shape of the cyst. However, the narrow end, which is regarded as anterior and which normally occupies the upper or basal end of the cyst, may be bent round so that it lies between the side of the animal and the cyst wall (Plate I, fig. 1) or it may be invaginated (Plate I, fig. 2). The length of a fully extended Turbellarian removed from a cyst may reach 5·0 mm. and its width at the widest part of its body 1·2 mm. Most specimens are yellowish in colour and the brownish yellow vitelline glands show faintly through the body wall as a dark mass.



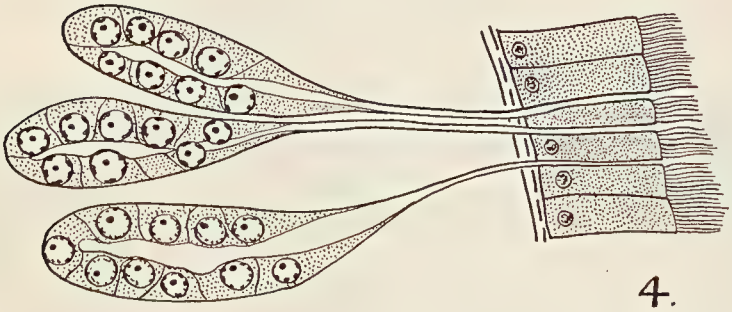
Acholades asteris sp. nov.

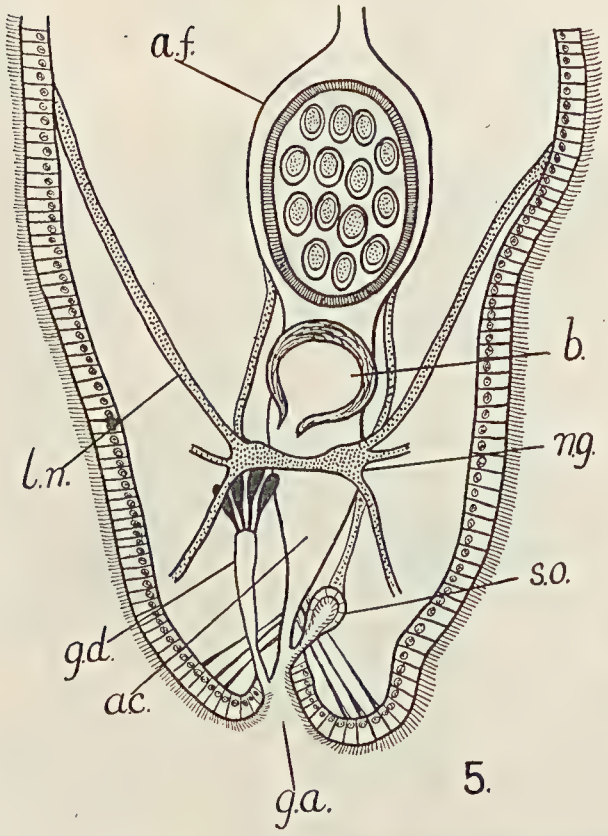
Ventral views showing general organization

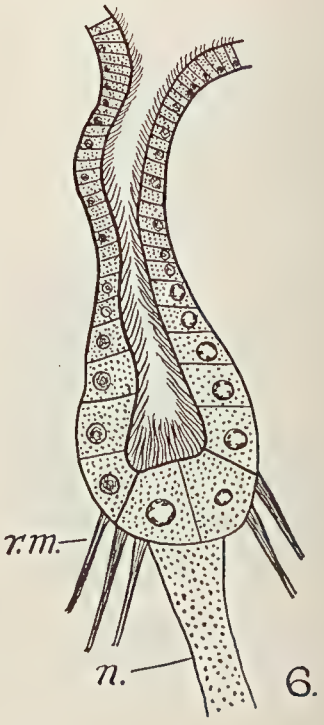
FIG. 1.—Usual form of specimen removed from cyst at side of tube-foot.

FIG. 2.—Specimen with invaginated anterior end.

FIG. 3.—Small specimen from sucker-disk of tube-foot.







Acholades asteris sp. nov.

FIG. 4.—A group of three glands opening on surface near genital aperture.

FIG. 5.—Ventral view of organs at posterior end of body in a fully extended specimen.

FIG. 6.—Longitudinal section of sensory organ.

In the small cysts found in the sucker-disk the animal is broadly oval in shape with the posterior end somewhat pointed and curved downward (text-fig. 3). Its length measures 0·50-0·65 mm. and its width 0·70-0·95 mm.

The surface of the body is completely clothed with cilia. There is no mouth. The genital aperture is situated at what is assumed to be the posterior end.

Body epithelium: The ciliated cells forming the body epithelium are columnar and measure 23-31 μ in height. Their nuclei are about 6 μ in diameter. Here and there between the bases of the columnar cells are large rounded interstitial cells about 10 μ in diameter and with nuclei of the same size as those of the columnar cells. A basement membrane appears to be absent and no gland cells or rhabdites are present. The epithelium is easily detached from the underlying muscular layer. When encysted specimens are fixed in Bouin's fluid they often contract leaving portions of the ciliated epithelium adhering to the connective tissue forming the wall of the cyst. This is clearly seen in Plate I, figs. 1 and 4.

Body musculature: Below the ciliated epithelium is a layer of circular muscles and below the circular muscles is a layer of longitudinal fibres. At the posterior end of the body the musculature is very strongly developed. The circular muscles round the genital aperture form a strong sphincter, which closes the opening, whilst the longitudinal muscles form a system of radial fibres which dilate the opening. There are no dorso-ventral muscles passing through the parenchyma.

Digestive system: There is no mouth, pharynx or intestine. However, the animal is able to invaginate its anterior end into the medullary parenchyma for a distance equal to about 1/4 of the length of the body (text-fig. 2; Plate I, fig. 2 and Plate II, figs. 5 and 6). The cavity of the invagination is usually filled with finely granular protoplasmic material and disintegrating cells, which are probably derived from the connective tissue of the tube-foot in which the parasite is encysted. The inner end of the invagination undergoes absorption and in some specimens large portions of the epithelium and musculature of the introvert can be seen in the medullary parenchyma, after the inner end of the invagination has been regenerated and evaginated. The mechanism by means of which invagination of the narrow anterior end is brought about presents a problem, since no retractor muscles are present.

Invagination was observed only in the larger forms encysted near the base of a tube-foot and not always in those cases. It was never observed in the smaller specimens encysted in the sucker-disk. Hence, it is not at all certain as to whether the process is a method of feeding, or whether it represents a condition imposed upon the parasite by a sudden contraction of the tube-foot of the host and the consequential contraction of the cyst in which the parasite is contained. Many specimens exhibit the condition and show different degrees of invagination and evagination (Plate II, figs. 5 and 6).

The medullary parenchyma contains numerous vacuoles enclosing food particles. Large portions of the parenchyma form a syncytium.

Nervous system and sense organs: A mass of nervous tissue resembling the brain of other Turbellarians is situated posteriorly below the atrium and near the ventral surface (text-fig. 5). It measures about 118 μ wide in the largest specimens and consists almost entirely of nerve fibres and very few nuclei. From it are given off three pairs of large nerves. One pair passes outwards and forwards to the body wall; a second pair passes posteriorly, one on each side of the atrium and the third pair passes upwards to the antrum femininum. A number of smaller nerves go to the body wall and adjacent organs.

The position of this nerve mass makes it difficult to define the correct orientation of the animal. In other Turbellarians the main nerve centre or brain is situated anteriorly and it might be claimed that the situation of the main nerve centre in the present species is also at the anterior end. Against this view, however, is the position of the genital aperture, which is situated posteriorly in the forms showing the closest relationship to the Turbellarian under consideration.

A sense organ in the form of a pear-shaped ciliated pit is situated posteriorly and opens into the atrium near the genital aperture (text-figs. 5 and 6). It measures 58-63 μ in length and 37-42 μ in the diameter of its widest part. Attached to its inner end are a number of retractor muscles and it is supplied with a nerve from the main nerve centre.

Reproductive system: The genital aperture opens into the genital atrium, which in the largest specimens measures about 432 μ long and 79 μ in diameter near the middle of its length. Its outer wall is provided with circular and longitudinal muscles. A number of strong dilator, retractor and protractor muscles extend out radially from its sides to the body wall. The lumen of the atrium is lined with club-shaped cells except immediately within the genital aperture, where it is lined with ciliated cells.

Situated above and slightly in front of the nerve centre is a spherical sac with strong fibrous muscular walls. It measures 79-123 μ in diameter and lies below or slightly to one side of the atrium into which it opens ventrally. It is regarded as a vestigial bursa. In addition to opening into the atrium it also opens into the parenchyma. Its lumen is often empty but in some cases contains spermatozoa, and in other cases degenerate cells. In some specimens indefinite channels in the parenchyma appear to open into it.

A group of very large club-shaped glands is situated immediately above and behind the nerve centre. In the largest specimens the glands measure 105 μ long and 18-32 μ in the diameter of the widest part. The glands open separately into the end of a common duct, which passes upward and opens into the atrium near the genital aperture (text-fig. 5).

In the posterior end of the animal are numerous smaller glands composed of elongate clusters of cells having very conspicuous nuclei about 5 μ in diameter. The ducts of these glands pass out between the cells of the body epithelium surrounding the genital aperture (text-fig. 4).

Well developed testes are found only in small specimens of the parasite, such as those encysted in the sucker-disk of the tube-foot. Usually two testes are present. They are pyriform or ovoid in shape

and measure 68-110 μ long and 52-55 μ wide. One is situated dorsally on the left side between the vitellaria and the germaria. The other is situated antero-ventrally between two of the vitelline lobes. Each testis gives rise to a short duct. The two ducts converge and enter the gonoduct (ductus communis) dorsally immediately above the entrances of the left and right germaria.

In large specimens, 3-5 mm. long, the testes have degenerated and have been replaced by masses of spermatozoa or disintegrating cells. Spermatozoa also often occur in small masses in the parenchyma in front of the vitellaria, below the shell-glands and at the sides of the antrum femininum.

The male reproductive system has no seminal vesicle, no ejaculatory duct and no copulatory organ.

The germaria are paired and situated one on each side immediately behind the vitellaria. Each is divided into four or five lobes, some of which extend anteriorly at the sides of the vitellaria and some posteriorly at the sides of the shell glands. The two germaria open into the gonoduct laterally immediately behind the vitellaria.

The vitellaria consist of a number of large yellowish brown pyriform or clavate lobes in the posterior half of the body. In well extended specimens they occur in the posterior 2/5. The lobes form a group in the medullary parenchyma and in non-contracted animals have their wide ends directed forwards (text-fig. 1). In most cases the lobes are single but may be divided in 2, 3 or 4 secondary lobes. They measure up to 1·18 mm. in length and 0·18 mm. in diameter at the widest part. Posteriorly the narrow ends converge and open close together into the anterior end of the gonoduct.

The gonoduct which corresponds with the ductus communis of other species extends from the vitellaria to the antrum femininum. It measures up to 419 μ in length and 53 μ in diameter. Its outer wall is provided with very weak circular muscles and strong longitudinal fibres. The circular muscles are more strongly developed at the junctions with the vitellaria and with the antrum feminium, in which places they probably act as sphincters.

The so-called shell glands lie immediately behind the entrances of the germaria into the gonoduct. They form a compact mass of pyriform cells completely surrounding the gonoduct. In transverse section the glandular mass measures 288-524 μ in diameter and occupies a large part of the centre of the field. The secretion in the narrow necks of the pyriform cells stains very darkly with haematoxylin. The cells do not open separately into the gonoduct. They are grouped together in clusters. Each cluster opens into a small diverticulum from the wall of the gonoduct.

Posteriorly the gonoduct opens into the antrum femininum. This is a large cavity in which the eggs collect and in which they become surrounded by an egg-capsule. In the non-extended condition of the parasite the antrum femininum is almost spherical. In the small forms encysted in the sucker-disk it measures 209-236 μ in diameter but in the larger specimens encysted in the side wall of the tube-foot it measures

353-458 μ in diameter. Posteriorly it opens into the genital atrium. Its outer wall is provided with circular, longitudinal and oblique muscles. It is lined by an epithelium of flat cells, which merge into club-shaped cells anteriorly and posteriorly. Strong proctractor and dilator muscles extend radially from its posterior end to the body wall. The cavity appears to function both as an antrum femininum and as a uterus.

Only a single egg-capsule is present at one time. In non-extended specimens it is spherical measuring 173-288 μ in diameter and having a wall 13-15 μ in thickness. In fully extended specimens the capsule becomes ovoid in shape. The yellowish material forming the wall of the capsule appears to be derived from the yolk, since it resembles in colour and appearance material associated with the yolk granules of the vitellaria. It does not in any way resemble the secretion of the so-called shell glands. If an egg-capsule is removed from a living animal and placed in sea-water in a Petri dish, it sinks to the bottom and soon adheres firmly to the dish. At the same time its colour becomes dark-brown.

It is estimated that 70 eggs or more may be contained in the capsule of a specimen about 5 mm. long. Each egg measures about 44 μ long and 39 μ in width and is enclosed in a delicate membrane. In some capsules the eggs exhibit early cleavage stages and blastomeres are scattered irregularly through the yolk of the egg. In addition to containing eggs the capsules also contain yolk granules and vitelline cells.

Habitat: Acholades asteris encysts in the connective tissue of the tube-feet of the sea-star, *Coscinasterias calamaria* (Gray).

Locality: All the Turbellarians, about 50 in number, examined during the preparation of the present paper, were taken from specimens of the host collected in D'Entrecasteaux Channel. Most of the sea-stars were dredged up from depths of about 6 fathoms during the months of May to August, 1951 and 1952, and March and April, 1953.

Infection of the host is often very heavy and it is not unusual to find 20 or more of the Turbellarians encysted in the tube-feet of one ambulacral groove. There is a tendency for the tube-feet near the apex of the groove to be more frequently parasitized than those at the base of the groove. Among 267 specimens of *Coscinasterias calamaria* taken in D'Entrecasteaux Channel 216 were observed to be infected.

The parasite also occurs in the same host at Spring Bay on the East Coast of Tasmania. Among 99 specimens of the sea-star collected at this locality in July, 1954, seventeen were infected.

Affinities: Although *Acholades asteris* lacks a mouth, pharynx and intestine, it possesses other features in which it shows rhabdocoel affinities. For example, the well-developed vitellaria, paired germaria, extensive shell-glands, posterior position of the genital aperture and the large antrum femininum containing the egg-capsule are features found also in the rhabdocoel family Umagillidae.

The absence of a mouth and pharynx has already been reported in the two genera *Fecampia* Giard (1886, p. 499) and *Glanduloderma* Jägersten (1941, p. 1). The former is parasitic in certain Isopods and crabs, the latter in Myzostomids. Both these genera have been placed

by Jägersten in the family Fecampiidae. However, *Acholades* differs from them in lacking epidermal rhabdites, a layer of sub-epidermal gland cells and an intestine. It also differs in having compact instead of diffuse vitellaria and in its main nerve centre being situated at the same end of the body as the genital aperture.

In the structure of its reproductive system and in lacking a mouth, pharynx and intestine, *Acholades asteris* differs widely from *Pterastericola fedotovi* Beklemicheff, the only other Turbellarian recorded as an endoparasite of a sea-star.

For these reasons it has been found necessary to erect the new family Acholadidae.

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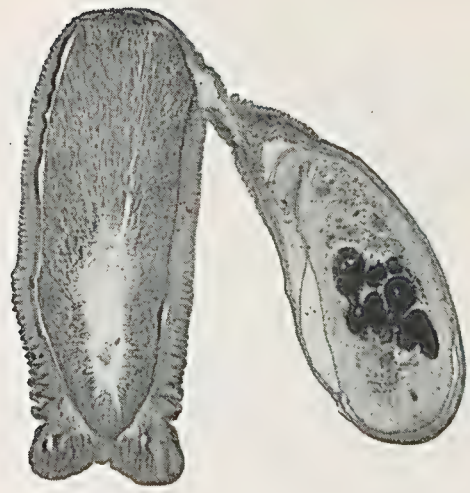
References to Text Figures and Plates

a.c.—Atrium genitale commune
a.f.—Antrum femininum
b.—Bursa
g.—Germaria
g.a.—Genital aperture
g.d.—Gland duct
inv.—Invagination
l.n.—Lateral nerve
n.—Nerve
n.g.—Nerve centre
r.m.—Retractor muscle
s.gl.—Shell-gland
t.—Testis
vi.—Vitellaria



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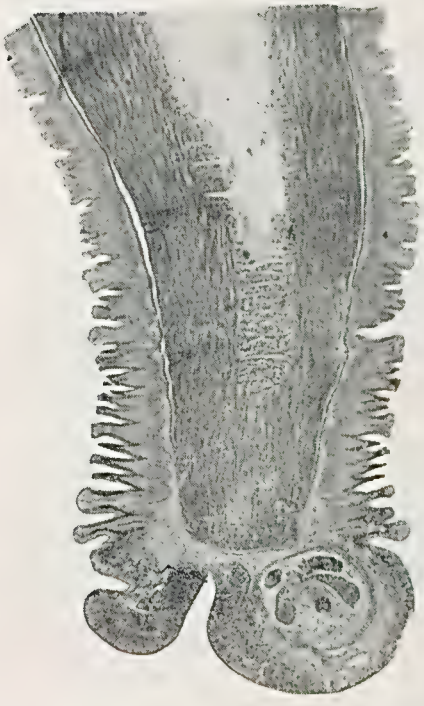

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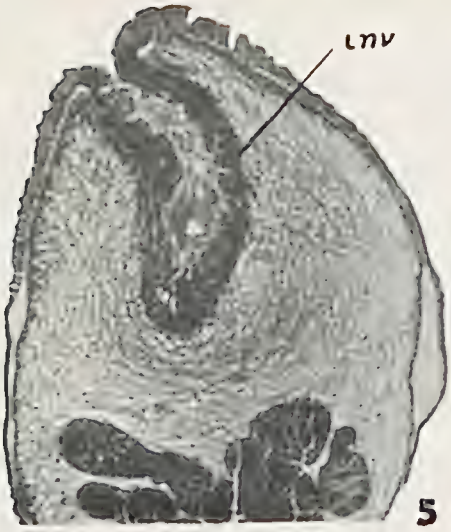
Acholades asteris sp. nov.

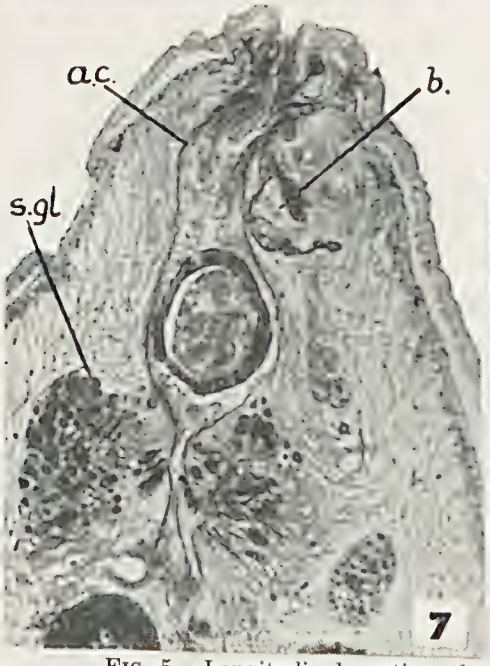
FIG. 1.—Longitudinal section through tube-foot of *Coscinasterias Calamaria* with encysted parasite at side. The anterior end of parasite is reflexed in the cyst.

FIG. 2.—Longitudinal section through tube-foot and encysted parasite. The anterior end of parasite is invaginated.

FIG. 3.—Longitudinal section through tube-foot showing small specimen of the parasite encysted in the sucker-disk.

FIG. 4.—Longitudinal or oblique sections through three encysted specimens of the parasite in the wall of one tube-foot.





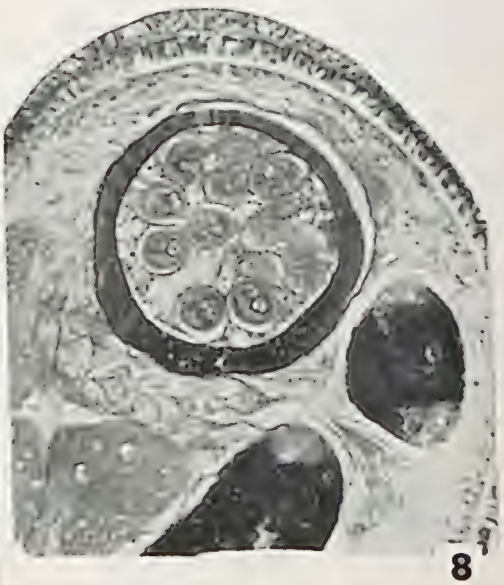


Fig. 5.—Longitudinal section through anterior end of a specimen of the parasite removed from a cyst. The anterior end is deeply invaginated and almost reaches the vitellaria.

Fig. 6.—Longitudinal section through anterior end of an encysted specimen of the parasite. The anterior end has been invaginated, partly absorbed and regenerated. The section shows the regenerated end being evaginated leaving remnants in the medullary parenchyma.

Fig. 7.—Part of a sagittal section through posterior end of the parasite showing genital atrium and the antrum femininum containing an egg-capsule.

Fig. 8 —Oblique section through posterior part of parasite showing the large thick-walled egg-capsule containing eggs which are undergoing cleavage.

Observations on the Hydrology of the River Derwent, Tasmania

By

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(with 6 text figures)

Abstract

This paper records a series of hydrological observations made on the River Derwent over a twenty month period. The salinity, pH and temperature of the river are shown. The salinity of the water at the bottom of the river at Millbrook Rise (Station 47) is 0 gms/^{00}. The surface salinity is zero at Boyer (Station 45). At Cadbury's (Station 5) the salinity of the bottom water is 30 gms/^{00}. The salinity gradient has been also worked out.

Introduction

This work was commenced as part of a survey which was intended to include the relationship between salinity and the distribution of marine forms in the estuary of the River Derwent and to obtain an estimate of the toleration of some species for fresh water. Only the hydrological results are recorded here.

The only work of major significance dealing with the hydrology of Australian estuarine waters is that of Rochford (1951). In this paper, he also reviews the more important overseas literature.

Rochford gives some figures relating to the Derwent Estuary as well as to the Huon River and D'Entrecasteaux Channel in the South.

The River Derwent was chosen for survey because it is convenient to Hobart and is suitable for boat work over most of the area of salt water penetration. It has the advantage of being reasonably free from factory pollution with the possible exception of two small areas which will be described below. For the purposes of this work it is intended that the lower limit of the survey will be an imaginary line drawn from Blinking Billy Point to Howrah.

All the tributaries of the river are small, both in size and volume of output into the river. The largest tributary is the River Jordan.

There are several sources of entry of foreign products into the river. The first of these lies at the Paper Mills at Boyer, the second at the Zincworks, and the third is the major sewage outfalls in and around the Port of Hobart. By European standards the river is virtually unpolluted. In the case of the two major industrial concerns, care is taken that no products are emptied into the river which would cause serious pollution.

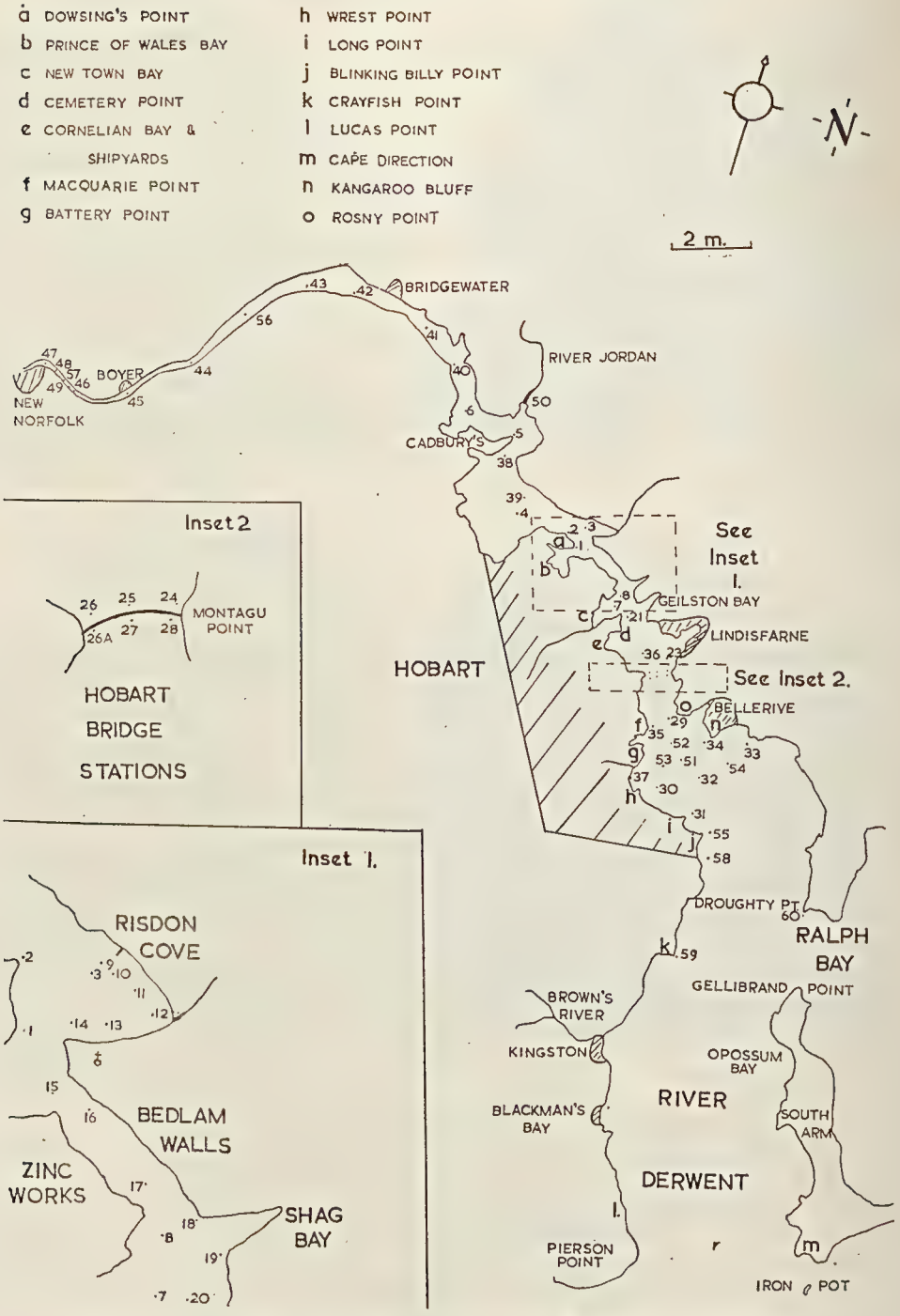

FIG. 1.—Map of the River Derwent showing Stations at which water samples were collected.

The Lower part of the river valley has been inundated by the sea since Glacial times. The shoreline of the area examined is rocky or stony with several areas of mud appearing at low water. The bottom, above Hobart Bridge, is muddy. Below the Bridge, this mud is slowly replaced by sand which is dominant at Long Point (Fig. 1).

A number of stations were established on the River. One of these stations (No. 1) was visited weekly and the remainder were the subject of occasional surveys. The stations are shown on the detailed list being deposited in the library of the Royal Society of Tasmania.

Methods

(*a*) *Period of Sampling*

Water samples were obtained by means of a Copenhagen water bottle fitted with reversible thermometers. The whole apparatus was lowered into the river attached to flexible steel wire. On most occasions the Stations were visited in a motor launch but on a few trips, a dinghy was used. The samples were brought to the surface and poured into 4 lb. Kilner jars, each of which was etched with a serial number. For samples which were not required for sediment measurements, either 1-lb. Kilner jars or other glass containers were used. After pH observations were made, the bottles were screwed up and transported to the laboratory at the University.

(*b*) *Temperature*

The temperature at the required depth, as shown on the reversing thermometer, was noted immediately the sample was brought on board the boat.

(*c*) *Depth*

The depth was determined by passing the wire holding the bottle over a metre wheel. This reading was compared with the depth as shown on Admiralty Chart No. 960 to allow for the drift of the apparatus. At certain stations it became unnecessary to use the metre wheel, as at Stations which were regularly sampled, the depth was known to within 1 foot. This method is not recommended for use where the tidal range is considerable but in view of the small tides at Hobart (average over 12 months being 1 foot $10\frac{1}{2}$ inches), the error involved is small. At the Stations in deep water, bottom samples were not taken. Bottom samples were not taken at the Bedlam Walls Stations due to the strong current operating there at all phases of the tide.

(*d*) *pH.*

pH readings were taken immediately the sample was poured into the Kilner Jar. Seven methods of pH determination were used. In the first stages of the investigation the pH was determined by a B.D.H. Thymol blue Capillator. A phenol red Capillator was used for one or two readings but was found to be unsatisfactory, since it gave readings which were widely different from those obtained by other methods. A diphenol purple capillator also was used.

Some readings were made using B.D.H. thymol blue, cresol red and diphenol purple comparators.

In the latter stages of the survey, a portable Jones pH electrometer was used. This instrument was very easy to use in the restricted space on the boat.

Table 2 shows the correlation between the readings obtained by the three methods.

TABLE 2

Correlation of pH readings obtained by the various methods.

Electrometer	Diphenol Purple Capillator 7·0-8·6	Thymol Blue Capillator 8·0-9·6	Thymol Blue Capillator	Diphenol Purple Capillator 7·2-8·6
9·6	....	9·5	....	....
8·3	8·4	8·6	8·3	8·1
7·62	7·6	....	....	7·5

(*e*) *Salinity*

The salinity was determined by a silver nitrate titration following the method outlined by Harvey (1945, p. 20). The correction factor given by Harvey was applied graphically to the result of the titration.

(*f*) *Sediment*

The amount of filterable sediment was obtained by passing the sample through a previously weighed Whatmans No. 1 Filter Paper. This was done as soon as possible after the sample arrived at the laboratory. The filter paper was washed with tap water and then distilled water to remove any salt. It was then dried and re-weighed. Each sample contained 1400 ccs. and the weight of sediment per litre was read off a graph.

(*g*) *Tabulation of Results*

The observations made on the boat were noted together with the bottle number of the sample. On arrival at the laboratory the relevant additional information was added and a note made of the index number of the filter paper used in the filtration of each sample. The filter paper weights and numbers were kept in a separate book with the bottle number and the date added as an additional check. When the filter paper was dry and re-weighed, all the information was transferred to stencilled sheets which were filed for future use.

On completion of filtration, all sample bottles were washed first in tap water and then in distilled water. They were then allowed to dry before being stored on board the boat for future use. It might be noted that all the usual precautions for obtaining accuracy were observed such as careful washing of the filtration apparatus, the burettes and conical flasks.

The results are shown in Tables 3 and 4 and graphed on figures 2-4.

TABLE 3

Hydrological data collected at various Stations in the Derwent Estuary.

Whenever a series of Stations was sampled in order to obtain a picture of the salinity gradient of the river, these results are all shown together and not under the records of each Station.

The methods of pH determination are indicated by:—

(1) Thymol blue capillator.
(2) Phenol red capillator.
(3) Thymol blue comparator.
(4) Diphenol purple comparator.
(5) Cresol red comparator.
(6) Electrometer.
(7) Diphenol purple capillator.

The data collected weekly at Station 1 are deposited in the library of the Royal Society of Tasmania.

STATION 1

Date	Station	Depth in fathoms S = Surface B = Bottom	Tide	River flow N.W. = normal winter; N.S. = normal summer	pH	Temperature (°C)	Salinity grs./mille	Sediment grs./litre
2/11/49	1	4 (B)	Flow	Heavy flood	7·6(1)	11·6	32·87	0·157
	....	3	Flow	Heavy flood	7·4(1)	11·9	21·43	0·162
	....	2	Flow	Heavy flood	7·0	12·5	5·1	0·072
	....	1	Flow	Heavy flood	7·0	12·7	5·5	0·060
	....	0	Flow	Heavy flood	7·0	12·4	5·1	0·048
	15	8 (B)	Flow	Heavy flood	8·0	11·55	33·2	....
	....	0 (S)	Flow	Heavy flood	7·0	11·9	3·8	....
	16	0 (S)	Flow	Heavy flood	7·0	12·75	3·6	....
	17	0 (S)	Flow	Heavy flood	7·0	12·3	3·72	....
	18	0 (S)	Flow	Heavy flood	7·0	12·3	3·5	....
	19	0 (S)	Flow	Heavy flood	7·2	12·8	3·67	....
	20	7 (B)	Flow	Heavy flood	8·0	....	32·75	....
	....	0 (S)	Flow	Heavy flood	7·0	12·2	4·1	....
	21	0 (S)	Flow	Heavy flood	7·0	12·3	4·85	....
	22	0 (S)	Flow	Heavy flood	7·0	12·6	5·4	....
	23	0 (S)	Flow	Heavy flood	7·2	12·6	5·4	....
	24	0 (S)	Flow	Heavy flood	7·2	13·0	5·3	....
	25	0 (S)	Flow	Heavy flood	7·2	12·7	5·1	....
	26	0 (S)	Flow	Heavy flood	7·2	12·9	6·0	....
	27	0 (S)	Flow	Heavy flood	7·2	12·5	10·36	....
	28	0 (S)	Flow	Heavy flood	7·4	12·5	11·17	....
	29	0 (S)	Flow	Heavy flood	7·6	13·1	12·19	....
	....	6 (B)	Flow	Heavy flood	8·2	11·3	33·65	....
	30	0 (S)	Flow	Heavy flood	7·4	13·6	13·19	....
	....	7 (B)	Flow	Heavy flood	8·4	11·4	33·62	....
	31	0 (S)	Flow	Heavy flood	7·7	13·4	18·73	....
	32	0 (S)	Flow	Heavy flood	7·7	13·0	20·62	....
	33	0 (S)	Flow	Heavy flood	7·7	12·9	17·03	....
	34	0 (S)	Flow	Heavy flood	7·7	12·45	18·23	....
	35	0 (S)	Flow	Heavy flood	7·0	12·8	10·16	....
	36	0 (S)	Flow	Heavy flood	7·0	12·5	5·938	....
11/1/50	1	4 (B)	Ebb	N.S.	8·4(1)	14·1	33·41	0·881
	1	3	Ebb	N.S.	8·0	14·2	30·11	0·410
	....	2	Ebb	N.S.	7·8	14·3	27·95	0·338
	....	1	Ebb	N.S.	8·0	14·7	25·18	0·380
	....	0 (S)	Ebb	N.S.	7·8	14·6	24·40	0·450

TABLE 3—*continued.*

Date	Station	Depth in fathoms S = Surface B = Bottom	Tide	River flow N.W. = normal winter; N.S. = normal summer	pH	Temperature (°C)	Salinity grs./mille	Sediment grs./litre
	3	6 (B)	Ebb	N.S.	8·4	14·0	33·02	....
	....	0 (S)	Ebb	N.S.	7·8	14·3	23·4	....
	39	4 (B)	Ebb	N.S.	8·2	13·8	33·02	....
	....	0 (S)	Ebb	N.S.	8·0	14·3	24·0	....
	38	3 (B)	Ebb	N.S.	8·0	14·3	28·15	....
	38	0 (S)	Ebb	N.S.	7·6	14·5	15·6	....
	5	4 (B)	Ebb	N.S.	8·0	14·5	33·04	....
	....	2	Ebb	N.S.	8·2	14·1	29·7	....
	....	0 (S)	Ebb	N.S.	7·4	14·55	14·20	....
	6	4 (B)	Ebb	N.S.	7·8	14·4	29·15	....
	....	0 (S)	Ebb	N.S.	7·4	14·4	12·99	....
	40	3 (B)	Ebb	N.S.	7·8	14·3	28·75	....
	....	0 (S)	Ebb	N.S.	7·2	14·3	11·48	....
	41	3 (B)	Ebb	N.S.	7·6	14·3	26·57	....
	....	0 (S)	Ebb	N.S.	7·4	14·15	9·36	....
	42	3 (B)	Ebb	N.S.	7·6	14·3	18·33	....
	....	0 (S)	Ebb	N.S.	7·0	14·3	3·8	....
	43	3 (B)	Ebb	N.S.	7·8	14·3	27·1	....
	....	0 (S)	Ebb	N.S.	7·0	14·3	3·2	....
	44	4 (B)	Ebb	N.S.	7·8	14·4	27·55	....
	....	0 (S)	Ebb	N.S.	7·0	....	2·1	....
	45	4 (B)	Ebb	N.S.	7·2	14·3	25·43	....
	....	0 (S)	Ebb	N.S.	7·0	14·3	not titratable	....
	46	5 (B)	Ebb	N.S.	7·25	14·4	20·13	....
	....	0 (S)	Ebb	N.S.	7·0	....	N.T.	....
	47	6 (B)	Ebb	N.S.	6·8	12·5	N.T.	....
	....	0 (S)	Ebb	N.S.	6·8	12·6	N.T.	....
	48	5 (B)	Ebb	N.S.	6·8	12·6	2·02	....
	....	0 (S)	Ebb	N.S.	7·0	....	N.T.	....
	49	5 (B)	Ebb	N.S.	7·2	13·0	7·54	....
	50	3 (B)	Flow	N.S.	7·6	....	21·97	....
3/3/50	1	4 (B)	Ebb	Subnormal S.	8·2	15·0	33·74	....
	....	3	Ebb	Subnormal S.	7·4	15·3	31·68	....
	....	2	Ebb	Subnormal S.	7·6	15·4	30·91	....
	....	1	Ebb	Subnormal S.	7·4	15·25	30·13	....
	....	0 (S)	Ebb	Subnormal S.	7·4	15·4	29·22	....
	3	0 (S)	Ebb	Subnormal S.	7·8	15·8	27·78	....
	18	0 (S)	Ebb	Subnormal S.	7·6	16·5	28·10	....
	22	0 (S)	Ebb	Subnormal S.	7·8	16·2	27·901	....
	23	0 (S)	Ebb	Subnormal S.	7·7	16·5	28·834	....
	24	0 (S)	Ebb	Subnormal S.	7·7	16·3	30·60	....
	25	0 (S)	Ebb	Subnormal S.	7·9	15·55	28·734	....
	26	0 (S)	Ebb	Subnormal S.	7·2	15·9	30·95	....
	26A	0 (S)	Ebb	Subnormal S.	7·5	15·55	29·72	....
	27	0 (S)	Ebb	Subnormal S.	7·9	15·45	30·80	....
	28	0 (S)	Ebb	Subnormal S.	7·7	15·45	30·61	....
	29	0 (S)	Ebb	Subnormal S.	8·3	15·8	31·26	....
	34	0 (S)	Ebb	Subnormal S.	8·6	15·8	33·036	....
	51	0 (S)	Ebb	Subnormal S.	8·4	17·0	31·29	....
	52	0 (S)	Ebb	Subnormal S.	8·2	16·0	32·26	....
	53	0 (S)	Ebb	Subnormal S.	8·3	15·95	32·068	....
22/6/50	1	4 (B)	Flow	N.W.	8·11	10·9	30·03	....
	....	3	Flow	N.W.	8·11	10·6	27·62	....
	....	2	Flow	N.W.	8·08	9·6	25·98	....
	....	1	Flow	N.W.	8·0	7·5	16·53	....
	....	0 (S)	Flow	N.W.	8·92	7·15	16·33	....
	3	6 (B)	Flow	N.W.	8·15	11·4	34·41	....
	3	0 (S)	Flow	N.W.	7·95	7·15	18·43	...

TABLE 3—*continued.*

Date	Station	Depth in fathoms S = Surface B = Bottom	Tide	River flow N.W. = normal winter; N.S. = normal summer	pH	Temperature (°C)	Salinity grs./mille	Sediment grs./litre
	4	4 (B)	Flow	N.W.	7·58	9·0	33·54	....
	....	0 (S)	Flow	N.W.	7·85	7·4	19·73	....
	38	5 (B)	Flow	N.W.	7·43	....	31·67	....
	....	0 (S)	Flow	N.W.	7·82	6·1	16·23	....
	5	4 (B)	Flow	N.W.	7·89	7·4	19·63	....
	....	0 (S)	Flow	N.W.	7·68	....	14·49	....
	6	4 (B)	Flow	N.W.	7·79	....	30·12	....
	....	0 (S)	Flow	N.W.	7·78	....	12·89	....
	40	4 (B)	Flow	N.W.	7·79	7·05	19·23	....
	....	0 (S)	Flow	N.W.	7·89	7·05	12·39	....
	41	3 (B)	Flow	N.W.	7·6	6·3	12·5	....
	....	0 (S)	Flow	N.W.	7·5	....	9·45	....
	42	3 (B)	Flow	N.W.	7·7	....	15·23	....
	....	0 (S)	Flow	N.W.	7·5	....	9·96	....
	56	3 (B)	Flow	N.W.	7·71	....	19·33	....
	....	0 (S)	Flow	N.W.	7·6	....	10·48	....
	43	3 (B)	Flow	N.W.	7·61	....	20·62	....
	....	0 (S)	Flow	N.W.	7·48	....	8·55	....
	44	3 (B)	Ebb	N.W.	7·5	....	21·4	....
	....	0 (S)	Ebb	N.W.	7·4	....	3·2	....
	45	3 (B)	Ebb	N.W.	7·76	....	21·61	....
	....	0 (S)	Ebb	N.W.	7·45	....	2·3	....
	46	5 (B)	Ebb	N.W.	7·5	....	21·3	....
	....	0 (S)	Ebb	N.W.	7·3	....	N.T.	....
	57	4 (B)	Ebb	N.W.	7·47	....	20·43	....
	....	0 (S)	Ebb	N.W.	7·62	....	N.T.	....
	49	4 (B)	Ebb	N.W.	7·38	....	20·73	....
	....	0 (S)	Ebb	N.W.	7·4	....	N.T.	....
17/11/50	1	4 (B)	Ebb	Summer with some flood	7·68 (6)	14·7	30·89	1·419
	....	3	Ebb	Summer with some flood	7·26	13·7	16·43	0·412
	....	2	Ebb	Summer with some flood	6·8	13·6	11·25	0·217
	....	1	Ebb	Summer with some flood	7·52	13·15	8·15	0·112
	....	0	Ebb	Summer with some flood	7·41	12·9	5·34	0·089
	3	6 (B)	Ebb	Summer with some flood	7·7	13·7	30·02	1·019
	....	0 (S)	Ebb	Summer with some flood	7·39	13·6	4·12	0·067
	18	0 (S)	Ebb	Summer with some flood	7·9	15·1	5·13	0·412
	20	0 (S)	Ebb	Summer with some flood	7·4	14·3	5·24	0·429
	26	0 (S)	Ebb	Summer with some flood	7·19	15·3	16·51	0·218
	28	0 (S)	Ebb	Summer with some flood	7·83	15·1	14·7	....
	29	0 (S)	Ebb	Summer with some flood	7·7	14·75	14·4	0·109
	34	0 (S)	Ebb	Summer with some flood	7·7	14·1	20·82	0·201
	54	0 (S)	Ebb	Summer with some flood	7·56	14·9	19·03	....
	55	0 (S)	Ebb	Summer with some flood	7·79	14·95	6·3	....

TABLE 3—*continued.*

Date	Station	Depth in fathoms S = Surface B = Bottom	Tide	River flow N.W. = normal winter; N.S. = normal summer	pH	Temperature (°C)	Salinity grs./mille	Sediment grs./litre
	30	0 (S)	Ebb	Summer with some flood	7·92	16·2	19·63	....
	35	0 (S)	Ebb	Summer with some flood	7·55	16·7	13·20	....
	39	5 (B)	Flow	Summer with some flood	7·78	13·7	30·70	....
	....	0 (S)	Flow	Summer with some flood	7·62	13·9	5·13	....
				SHORT RIVER SURVEYS				
7/7/49	1	4 (B)	Flow	Some flood	8·4 (1)	9·0	....	0·520
	....	3	Flow	Some flood	8·3	7·8	....	0·200
	....	2	Flow	Some flood	7·6	6·1	....	0·018
	....	1	Flow	Some flood	7·5	6·1	....	0·078
	....	0 (S)	Flow	Some flood	7·2	6·1	....	0·105
	4	4 (B)	Flow	Some flood	7·9	8·9	....	0·400
	....	3	Flow	Some flood	8·2	6·2	....	0·100
	....	2	Flow	Some flood	7·7	6·1	....	0·185
	....	1	Flow	Some flood	7·2	5·9	....	0·375
	....	0 (S)	Flow	Some flood	7·2	6·1	....	0·200
	5	4 (B)	Flow	Some flood	8·0	8·9	....	0·525
	....	3	Flow	Some flood	7·9	7·1	....	0·185
	....	2	Flow	Some flood	7·6	5·6	....	0·015
	....	1	Flow	Some flood	7·1	5·6	....	0·038
	....	0 (S)	Flow	Some flood	7·2	6·0	....	0·086
	6	4 (B)	Flow	Some flood	8·2	7·1	....	0·167
	....	3	Flow	Some flood	7·9	6·9	....	0·188
	....	2	Flow	Some flood	7·4	5·8	....	0·100
	....	1	Flow	Some flood	7·1	4·9	....	0·035
	....	0 (S)	Flow	Some flood	7·2	5·25	....	0·033
	7	6 (B)	Flow	Some flood	8·1	9·9	....	0·625
	....	4½	Flow	Some flood	7·5	7·1	....	0·089
	....	3	Flow	Some flood	7·0	6·8	....	0·100
	....	1½	Flow	Some flood	7·2	7·1	....	0·089
	....	0 (S)	Flow	Some flood	7·0	7·0	....	0·050
13/10/49	1	4 (B)	Flow	Flood	7·8	11·0	31·1	0·305
	....	3	Flow	Flood	7·4	11·9	28·54	0·129
	....	2	Flow	Flood	7·0	11·9	18·2	0·127
	....	1	Flow	Flood	7·2	12·2	7·15	0·171
	....	0	Flow	Flood	7·0	12·6	5·54	0·150
	9	1	Flow	Flood	7·2	12·6	10·8	0·136
	10	1	Flow	Flood	7·2	13·0	10·6	0·113
	11	1	Flow	Flood	7·2	12·7	10·15	0·219
	12	1	Flow	Flood	7·2	12·8	10·60	0·258
	13	1	Flow	Flood	7·2	12·7	10·62	0·113
	14	1	Flow	Flood	7·2	12·2	10·89	0·038
8/6/50	1	4 (B)	Flow	N.W.	8·13	10·8	33·0	....
	....	3	Flow	N.W.	7·82	9·6	27·26	....
	....	2	Flow	N.W.	7·5	9·35	22·92	....
	....	1	Flow	N.W.	7·6	8·1	17·9	....
	....	0	Flow	N.W.	7·72	6·8	15·9	....
	17	6	Flow	N.W.	8·3	11·2	33·83	....
	....	0 (S)	Flow	N.W.	8·05	6·4	15·0	....
	19	0 (S)	Flow	N.W.	8·1	7·2	14·90	....
	20	0 (S)	Flow	N.W.	8·5	7·15	15·42	....
	26	0 (S)	Flow	N.W.	7·6	6·95	17·63	....

TABLE 3—*continued.*

Date	Station	Depth in fathoms S = Surface B = Bottom	Tide	River flow N.W. = normal winter; N.S. = normal summer	pH	Temperature (°C)	Salinity grs./mille	Sediment grs./litre
	29	0 (S)	Flow	N.W.	7·9	3·3	21·62	....
	34	0 (S)	Flow	N.W.	8·12	3·7	26·57	....
	31	0 (S)	Flow	N.W.	8·21	7·7	26·77	....
	32	0 (S)	Flow	N.W.	8·08	8·0	26·25	....
24/1/51	1	4 (B)	Ebb	Subnormal S.	8·1	17·65	30·3	0·929
	....	3	Ebb	Subnormal S.	7·7	19·1	24·59	0·392
	....	2	Ebb	Subnormal S.	7·6	18·95	19·23	0·195
	....	1	Ebb	Subnormal S.	7·6	18·05	18·72	0·079
	....	0	Ebb	Subnormal S.	7·4	18·3	17·3	0·020
	18	0 (S)	Ebb	Subnormal S.	7·6	17·1	15·22	0·107
	20	0 (S)	Ebb	Subnormal S.	7·9	16·9	16·23	0·039
	29	0 (S)	Ebb	Subnormal S.	8·0	18·6	22·22	....
	31	0 (S)	Ebb	Subnormal S.	8·1	19·6	25·38	0·142
	58	0 (S)	Ebb	Subnormal S.	7·9	20·6	20·42	0·200
	59	0 (S)	Ebb	Subnormal S.	8·2	20·5	30·98	0·121
	60	0 (S)	Ebb	Subnormal S.	8·2	19·0	30·40	0·094
				OCCASIONAL STATIONS				
16/6/49	2	3 (B)	Flow	N.W.	8·3	10·8	....	0·316
	....	2½	Flow	N.W.	8·0	10·5	....	0·178
	....	1½	Flow	N.W.	7·2	7·7	....	0·125
	....	1	Flow	N.W.	7·0	7·5	....	0·154
	....	0 (S)	Flow	N.W.	7·2	8·0	....	....
23/6/49	3	6 (B)	Flow	Slight flood	8·0	10·6	....	0·167
	....	4½	Flow	Slight flood	7·6	9·05	....	0·165
	....	3	Flow	Slight flood	7·6	6·4	....	0·095
	....	1½	Flow	Slight flood	7·1	5·9	....	0·085
	....	0 (S)	Flow	Slight flood	7·05	5·9	....	0·050
25/6/49	4	5 (B)	Flow	Slight flood	8·0	10·65	....	0·220
8/9/49	8	7 (B)	Ebb	N.W.	8·0	10·15	....	1·254
	....	5½	Ebb	N.W.	8·0	10·9	....	0·167
	....	3½	Ebb	N.W.	8·0	10·45	....	0·164
	....	1½	Ebb	N.W.	7·6	10·5	28·95	0·075
	....	0 (S)	Ebb	N.W.	7·2	10·7	....	0·084
24/9/49	9	2 (B)	Flow	N.W.	8·0	10·7	....	0·355
	....	1½	Flow	N.W.	7·2	10·7	....	0·115
	....	1	Flow	N.W.	7·5	9·9	....	0·103
	....	½	Flow	N.W.	7·5	10·1	13·65	0·137
	....	0 (S)	Flow	N.W.	7·2	10·3	....	0·138
24/12/49	3	6 (B)	Ebb	N.S.	8·0	14·2	32·86	....
	....	4½	Ebb	N.S.	7·8	14·45	27·16	....
	....	3	Ebb	N.S.	7·4	15·25	23·12	....
	....	0 (S)	Ebb	N.S.	7·2	15·8	14·20	....
	4	0 (S)	Ebb	N.S.	7·1	15·6	7·89	....
26/1/50	3	6 (B)	Ebb	N.S.	8·4	14·4	33·83	....
	....	3	Ebb	N.S.	8·0	15·6	29·92	....
	....	0 (S)	Ebb	N.S.	7·6	13·8	17·73	....
2/2/50	17	0 (S)	Ebb	Subnormal S.	7·2	20·1	18·83	....
	19	0 (S)	Ebb	Subnormal S.	7·0	17·0	19·03	....
	21	0 (S)	Ebb	Subnormal S.	7·0	17·5	21·12	....
10/11/50	39	0 (S)	Flow	N.W.	9·52	14·3	28·65	0·462
	4	0 (S)	Flow	N.W.	8·73	15·3	11·2	0·161

TABLE 4

Monthly averages of data obtained at Station 1

Date		pH	Temperature	Salinity
6/49	Bottom	7·9	10·2	....
	3	7·3	9·3	...
	2	7·2	8·0	....
	1	7·1	7·4	....
	0	7·3	7·3	....
7/49	Bottom	8·1	9·3	....
	3	7·6	7·7	....
	2	7·4	7·4	....
	1	7·2	7·6	....
	0	7·2	6·8	....
8/49	Bottom	8·5	10·25	33·77
	3	7·5	9·4	23·06
	2	7·6	8·5	22·07
	1	7·6	8·5	21·67
	0	7·6	8·8	20·44
9/49	Bottom	8·1	10·4	33·3
	3	7·9	10·1	26·17
	2	7·5	10·2	22·42
	1	7·3	9·6	19·40
	0	7·3	9·5	18·43
10/49	Bottom	8·0	11·3	32·16
	3	7·6	11·3	26·68
	2	7·3	11·1	17·79
	1	7·2	10·9	10·95
	0	7·2	11·2	10·07
11/49	Bottom	8·1	12·2	32·80
	3	7·9	13·4	26·36
	2	7·2	14·6	16·53
	1	7·4	14·5	10·92
	0	7·3	15·1	9·68
12/49	Bottom	8·2	13·8	32·56
	3	7·7	14·0	30·52
	2	7·3	14·2	23·76
	1	7·2	14·3	18·00
	0	7·3	14·1	17·35
1/50	Bottom	8·0	14·7	33·23
	3	7·7	14·8	29·74
	2	7·5	14·8	26·89
	1	7·5	14·8	25·64
	0	7·4	15·1	23·63
2/50	Bottom	7·9	15·6	33·08
	3	7·6	15·9	29·18
	2	7·2	15·8	26·77
	1	7·3	16·5	17·93
	0	7·1	16·5	16·98
3/50	Bottom	7·8	15·1	32·09
	3	7·4	14·8	26·89
	2	7·3	14·5	23·94
	1	7·2	14·3	21·91
	0	7·3	14·5	21·18
4/50	Bottom	7·4	14·4	31·87
	3	7·2	13·6	28·25
	2	7·0	13·7	24·69
	1	7·0	12·7	17·52
	0	7·0	12·8	16·71

TABLE 4—*continued.*

Date		pH	Temperature	Salinity
5/50	Bottom	7·6	13·8	30·65
	3	7·6	12·5	23·66
	2	7·6	12·7	21·91
	1	7·2	11·9	18·86
	0	7·4	11·7	18·42
6/50	Bottom	8·1	11·3	32·01
	3	7·8	10·3	25·38
	2	7·5	9·4	22·58
	1	7·5	8·4	16·04
	0	7·7	7·7	15·24
7/50	Bottom	8·2	....	34·50
	3	7·8	....	29·69
	2	7·7	....	24·09
	1	7·4	....	16·01
	0	7·3	....	13·59
8/50		No records		
9/50	Bottom	8·3	10·4	33·72
	3	7·0	....	6·84
10/50		No records		
11/50	Bottom	7·3	14·6	25·82
	3	7·3	14·1	20·61
	2	7·3	14·3	18·03
	1	7·3	14·1	14·15
	0	7·3	13·9	12·58
12/50		No records		
1/51	Bottom	8·2	18·1	30·30
	3	7·8	18·7	26·67
	2	7·5	19·5	20·47
	1	7·5	19·0	19·27
	0	7·2	18·8	17·01
2/51	Bottom	8·0	18·8	28·23
	3	7·6	18·3	23·10
	2	7·6	18·8	21·41
	1	7·5	18·5	20·76
	0	7·4	19·2	20·45
3/51	Bottom	8·2	17·9	31·86
	3	7·9	17·5	27·64
	2	7·5	17·3	26·68
	1	7·6	17·9	26·40
	0	7·8	18·2	27·31
Average salinity from 6/1949 to 3/1951 inclusive				31·76
				29·60
				22·92
				18·46
				17·44

TABLE 5

Estimated average monthly discharge (in cu. secs.) of River Derwent for period May 1949-December 1950. Data are based on figures supplied by the Hydro-Electric Commission.

May 1949	3366	March	2145
June	2920	April	2376
July	8510	May	2387
August	4640	June	2761
September	3663	July	3162
October	4884	August	4367
November	4333	September	5511
December	2778	October	3377
January 1950	2760	November	4169
February	2000	December	2453

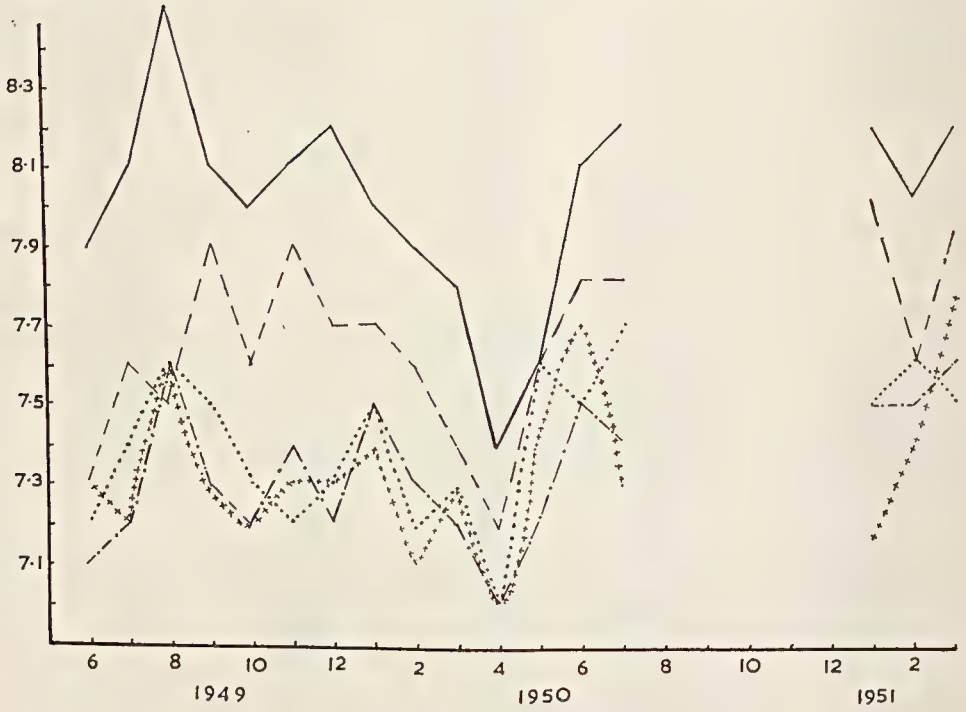

FIG. 2.—Average monthly pH values taken at Station 1 from June 1949 to March 1951. The unbroken line shows the pH at the bottom (4 fathoms); the pH at three fathoms is shown by a broken line; the pH at two fathoms by a dotted line; the pH at one fathom by a line of dashes and dots, and the surface pH by a line of crosses.

The monthly average for the period 1922-1953 is 5123 cu. secs. These results, as shown in Figs. 2-4 can be compared with Fig. 5, which shows the average monthly discharge of the river (Table 5) as kindly given to me by the Hydro-Electric Commission. The bottom salinity at Station 1 is fairly constant throughout the year, the greatest variation occurring during the winter months. This is to be expected since there is a greater flow of fresh water at that time of the year. The temperature varies considerably throughout the year. In general, the temperature variation follows that of the coastal waters further down the River Derwent (Station 37, see Guiler, 1950). The pH value does not appear to follow closely any of the other two factors though it apparently follows the amount of discharge from the river, the more acid freshwater being present during times of flood. The bottom pH varies more than that at other depths, this probably being due to more interchange with the alkaline salt water at this depth than nearer the surface where the pH is more acid.

Limits of saltwater and freshwater influences

The river is tidal as far as New Norfolk but the limit of salt water penetration ends below the town, in the part of the river below Millbrook Rise (Station 46). During a summer survey, the surface salinity became so low at Station 45, off Boyer, that it was not possible to estimate by titration the salts in the sample. The bottom salinity at this Station was still high (25-43 grs./^{00}) but at Station 47, below New Norfolk the bottom salinity was 1. Station 48 (see Fig. 1) had a bottom salinity of 2·02 grs./^{00}. The salinity gradient in this part of the river is steep. It is surprising that during the winter survey the salinities at these Stations were higher than those obtained during the summer. Reference to Fig. 5 shows that the actual discharge from the river was less during this period than in the summer, due to an abnormally dry winter period.

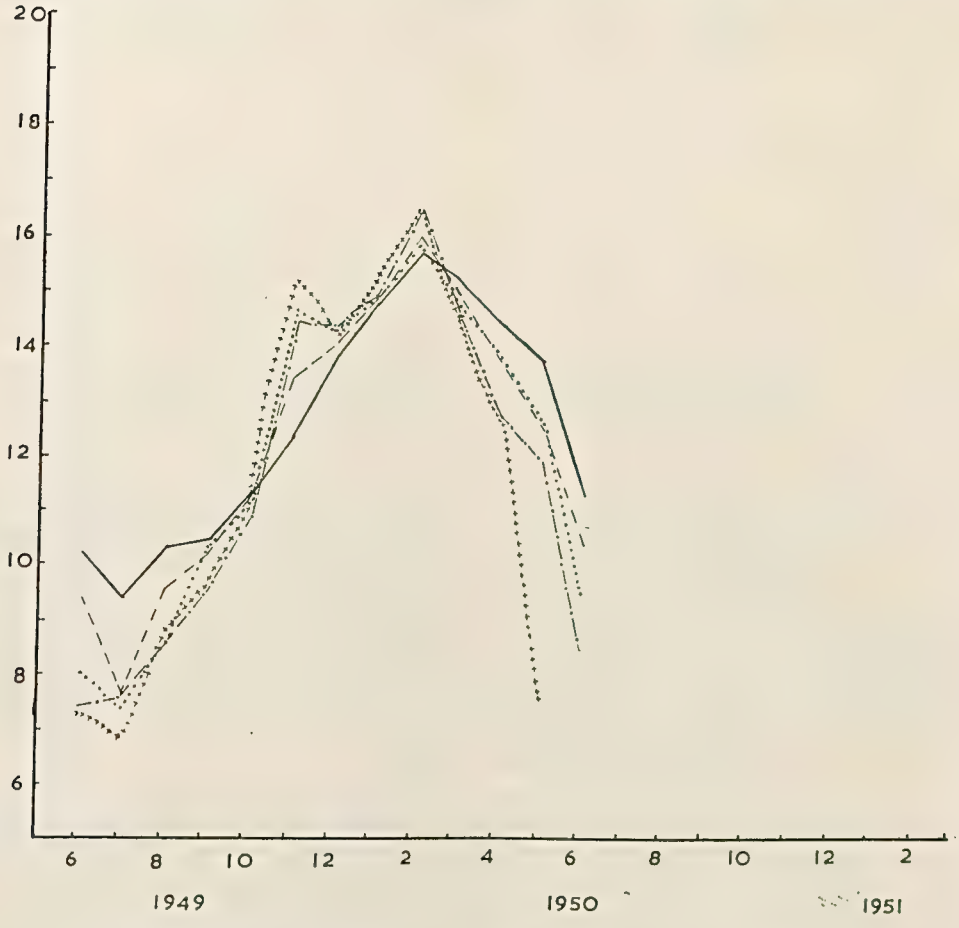

FIG. 3.—Average monthly temperature (° C) taken at Station 1 from June 1949 to March 1951. The conventions are the same as in Figure 2.

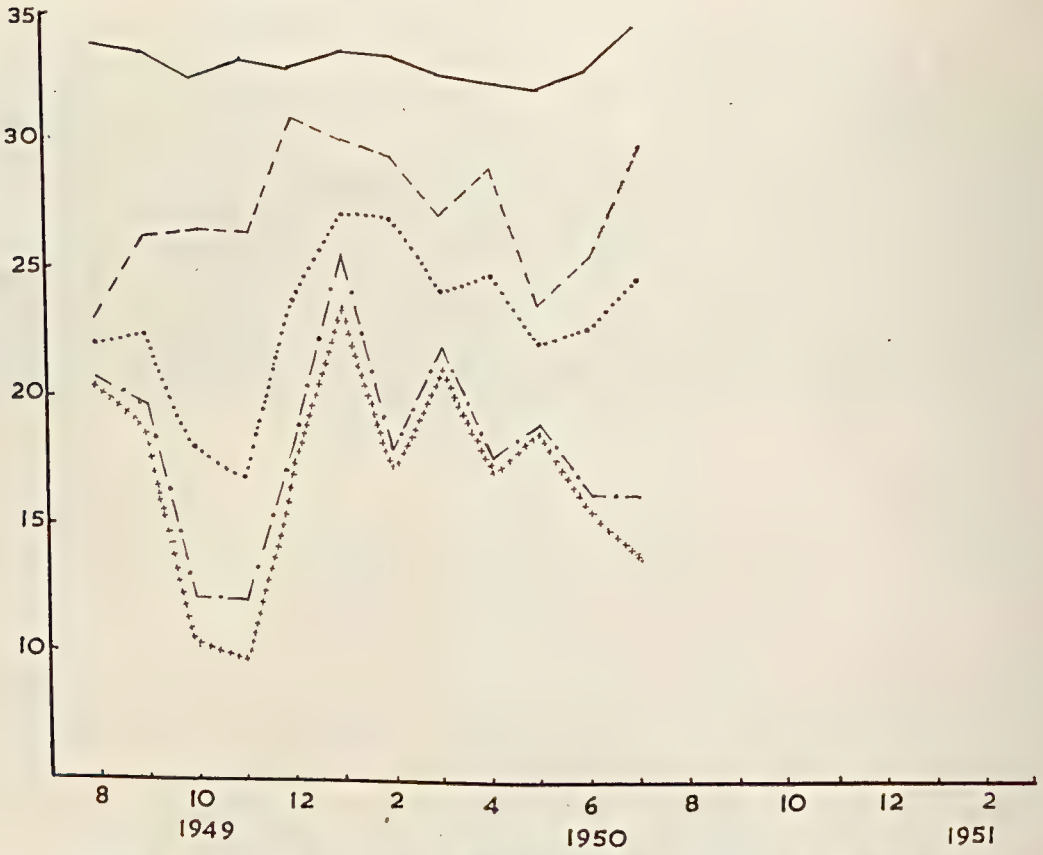

FIG. 4.—Average monthly salinities (in grs./^{00}) taken at Station 1 from June 1949 to March 1951. The conventions are the same as in Figure 2.

During flood periods the fresh water extends for considerable distances down either side of the estuary. The distance the freshwater extends down the eastern side of the river is greater than that on the western shore. During floods, the freshwater can be seen as a brown colouration carried down by the river, extending as far as Opossum Bay on the eastern shore while Blackman's Bay on the western shore is unaffected by the flood. During a period of flood the water on a line between Long Point and Howrah (Stations 31, 32, 33) had a surface salinity of 17-20 grs./^{00}, with a pH in accordance with marine figures. The result taken on 17/4/50 at Station 55 must be regarded as very doubtful since the Station is situated near drainage and sewage outfall.

It is thus possible to construct a salinity gradient diagram for the River Derwent (Fig. 6). It must be stressed that the salinity gradient at any one station may vary considerably from that shown above, depending on the flow of fresh water. Unfortunately, the period over which water sampling was carried out was exceptionally dry.

Following the nomenclature proposed by Rochford, the part of the river above Boyer (Station 45) falls into the freshwater zone, the region above Station 1 forms the gradient zone, the region below

Station 1 as far as Cornelian Bay is the tidal zone while below this area is the marine zone.

There is considerable biological evidence that there has been a comparatively recent change in the hydrological character of the river. Species which used to occur in several of the upstream bays about 20 years ago are no longer found there, e.g., Pectinidae in New Town Bay. The biological results of dredging in New Town Bay used to yield species characteristic of a sandy bottom but nowadays the bay is very muddy and the species found are characteristic of that habitat. Dredging off Station 1 produced a dredge full of *Echinocardium cordatum*, whereas in earlier times, oysters and scallops were found among other marine species.

These faunal changes were brought about by greater agricultural effort increasing the run-off as well as the amount of sediment brought down by the river. The sediment caused silting of the river bed and so altered the fauna.

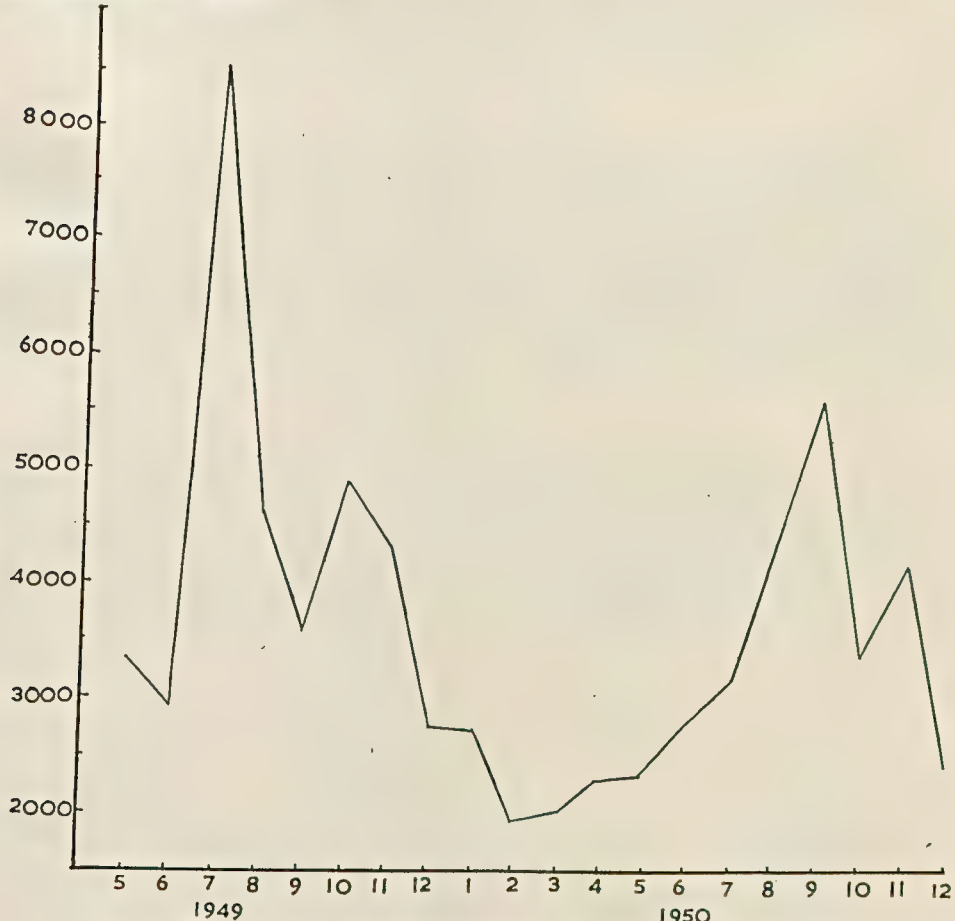

FIG. 5.—The average monthly discharge (in cu. secs.) of the River Derwent for the period from May 1949 to December 1950. Based on data kindly supplied by the Hydro-Electric Commission.

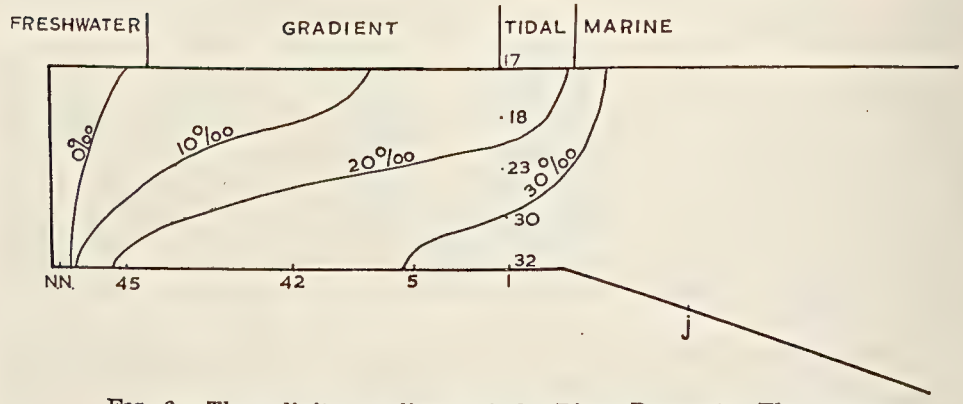

FIG. 6.—The salinity gradients of the River Derwent. The nomenclature used is that of Rochford (1951). The conventions are:—N.N.—New Norfolk; 45, 42, 5, 1—Station numbers inserted as reference points; j—Blinking Billy Point; 32, 30, 23, 18, and 17—the salinities at four, three, two, one and zero fathoms.

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Two New rhabdocoel Turbellarians parasitic in Tasmanian Holothurians

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(with 13 text figures and 3 plates)

Abstract

A list of the valid species of rhabdocoel Turbellarians recorded as endoparasites of Holothurians is given. Two new species are described. One of these occurs in the intestine of *Mensamaria thomsoni* (Hutton) and belongs to a new genus. It is named *Notothrix inquilina* gen. et sp. nov. The second species is found in the intestine of *Stichopus mollis* (Hutton) and belongs to the genus *Ozametra* Marcus. It is named *Ozametra striata* sp. nov.

Introduction

The rhabdocoel Turbellarians recorded as endoparasites of Holothurians all belong to the family Umagillidae (Wahl, 1910). In a recent revision of the family Stunkard and Corliss (1951, p. 324) record 13 valid and 5 doubtful species from sea-cucumbers. Westblad (1953, p. 269) has re-established one of the doubtful species, namely, *Anoplodium graffi* Monticelli, and described three new forms. Of these one, *Anoplodiopsis gracilis*, is recorded as doubtfully synonymous with *Anoplodium gracile* Wahl. whilst another, *Ozametra elegans*, is stated to be the species, which Bock (in Westblad, 1926, p. 212) assigned to the genus *Umagilla* but did not describe.

It would seem, therefore, that 16 valid species of rhabdocoel Turbellarians parasitic within Holothurians are now recognized. These are listed in the following table.

Turbellarian	Holothurian host	Site in host	Locality
Anoplodiera voluta Westblad, 1930	*Stichopus tremulus* (Gunnerus)	Intestine	West Coast of Norway
Anoplodiopsis gracilis Westblad, 1953	*Holothuria forskali* Delle Chiaje	Body cavity	Naples, Italy
Anoplodium evelinae Marcus, 1949	Holothurians	Body cavity	Bay of Santos, Brazil
Anoplodium graffi Monticelli, 1892	*Holothuria impatiens* Forskal	Body cavity	Naples, Italy
Anoplodium mediale Ozaki, 1932	*Stichopus japonicus* Selenka	Body cavity	Hiroshima, Japan
Anoplodium parasita Schneider, 1858	*Holothuria tubulosa* Gmelin	Body cavity	Naples, Italy
Anoplodium stichopi Bock, 1926	*Stichopus tremulus* (Gunnerus)	Body cavity	West Coast of Norway
Anoplodium tubiferum Westblad, 1953	*Holothuria forskali* Delle Chiaje	?	Plymouth, England
Cleistogamia holothuriana Faust, 1924	*Actinopyga mauritiana* (Quoy and Gaimard)	Intestine	Andaman Seas
Cleistogamia loutfia (Khalil and Azim), 1937	Holothurians	Intestine	Hourghada, Red Sea

Turbellarian	Holothurian host	Site in host	Locality
Macrogynium ovalis Meserve, 1934	*Stichopus* sp.	Intestine	Bermuda
Monticellina longituba Westblad, 1953	*Holothuria impatiens* Forskal and *Holothuria polii* Delle Chiaje	Body cavity	Naples, Italy, and Rovinj, Yugoslavia
Ozametra arbora (Ozaki), 1932	*Stichopus japonicus* Selenka	Intestine	Hiroshima, Japan
Ozametra elegans Westblad, 1953	*Stichopus tremulus* (Gunnerus)	Intestine	West Coast of Norway
Umagilla forskalensis Wahl, 1906	*Holothuria forskali* Delle Chiaje	Fore-gut	Naples, Italy
Wahlia macrostylifera Westblad, 1930	*Stichopus tremulus* (Gunnerus)	Intestine	West Coast of Norway

Westblad (1953, p. 276) gives a diagnosis of the genus *Anoplodium* and states that the species are " Parasites in the intestine of sea-cucumbers ". This seems to be an error since of the six species mentioned in the above table five are recorded as occurring in the body cavity of the host. The precise location in its host of the remaining species, *Anoplodium tubiferum,* Westblad, is not mentioned in the original description.

In the present paper two new parasitic rhabdocoels found in Tasmanian Holothurians are described. One, *Notothrix inquilina* gen. et sp. nov., is from the intestine of the small bluish sea-cucumber, *Mensamaria thomsoni* (Hutton), collected under stones at low tide near Fossil Island, Eaglehawk Neck. The other, *Ozametra striata* sp. nov. is from the intestine of the large sea-cucumber, *Stichopus mollis* (Hutton), taken in D'Entrecasteaux Channel.

With the exception of *Anoplodium evelinae* Marcus from Holothurians in the Bay of Santos, Brazil, the two Tasmanian species appear to be the only parasitic rhabdocoels so far recorded from Holothurians in the Southern Hemisphere.

Descriptions

Order: NEOOPHORA

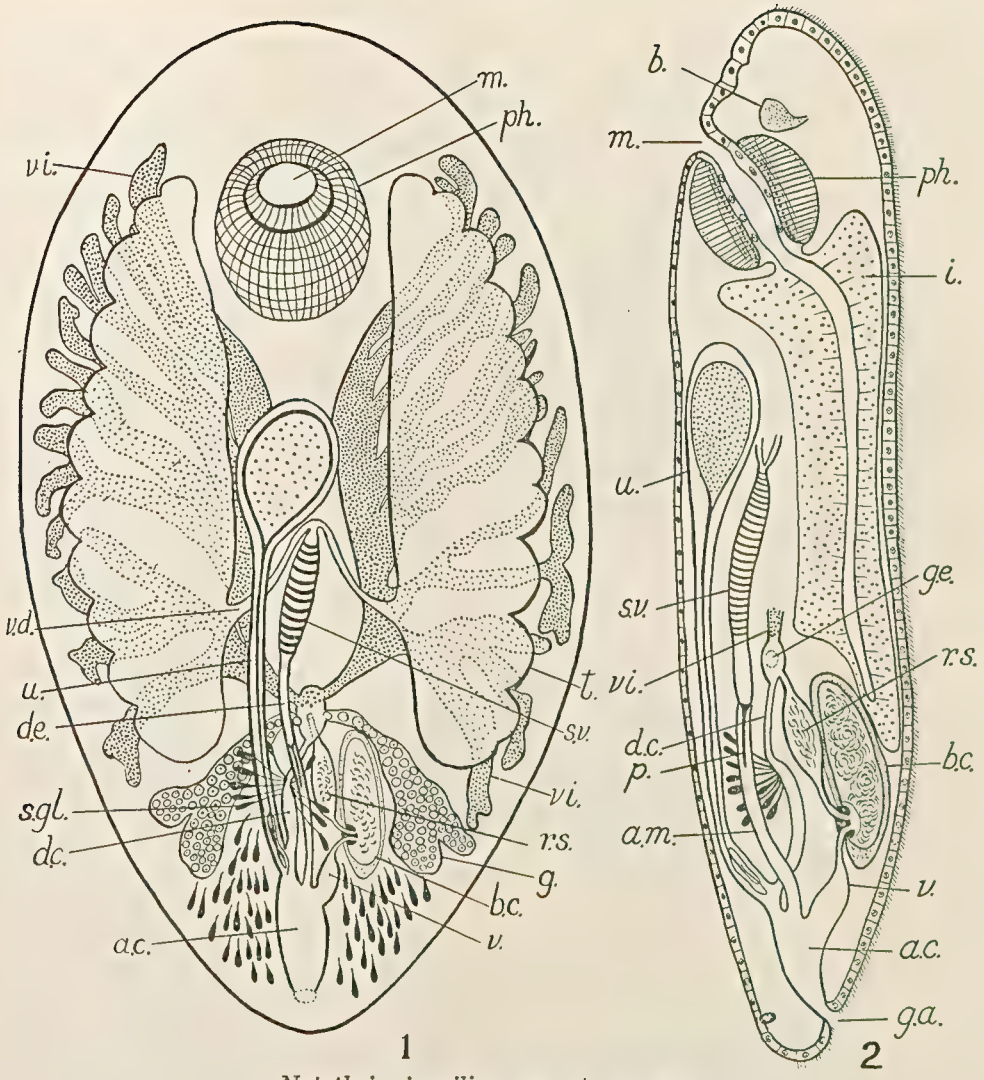
Sub-order: Neorhabdocoela

Family: Umagillidae Wahl, 1910

Genus: *Notothrix* nov.

Definition of genus: Umagillidae with dorsal surface of body ciliated, ventral surface non-ciliated. Large pharynx doliiformis at anterior end of intestine. Germaria paired and lobed. Testes paired, lateral, long and lobed. Vitellaria paired, separate and dendritic. Penis in the form of a stylet lying in a tubular non-ciliated antrum masculinum. Vagina leading into a glandular bursa copulatrix. Genital aperture dorsal and near posterior end.

Type of genus: *Notothrix inquilina* sp. nov.



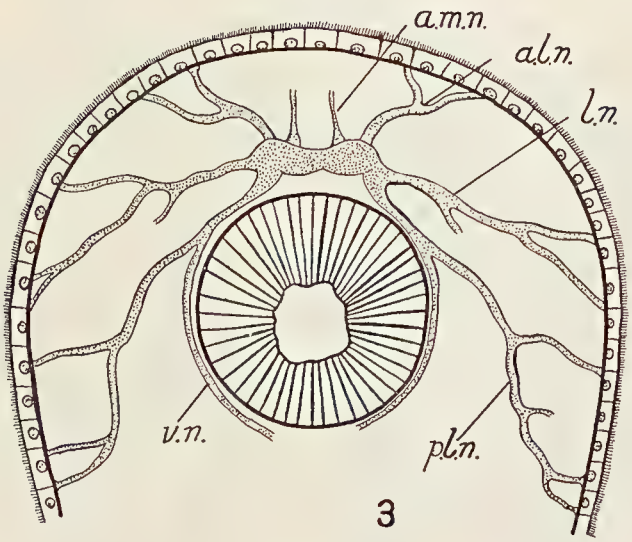
Notothrix inquilina gen et sp. nov.

FIG. 1.—Ventral view of general organization.
FIG. 2.—Sagittal section.

Notothrix inquilina sp. nov.

(TEXT FIGURES 1-6. PLATES I AND III)

External features: Living specimens are somewhat leaf-shaped, wide and rounded in front and becoming narrower posteriorly. The length of mature individuals after fixation 1·0-1·6 mm.; the width 0·45-0·67 mm. The dorsal surface is convex and clothed with cilia. The ventral surface is usually concave in life but somewhat convex in preserved specimens. The body is white and translucent, the yellowish vitellaria and egg-capsule being clearly visible. The mouth is in a median position on the ventral surface about 1/7 of the length of the animal from the anterior end. The genital aperture is near the posterior end and on the dorsal



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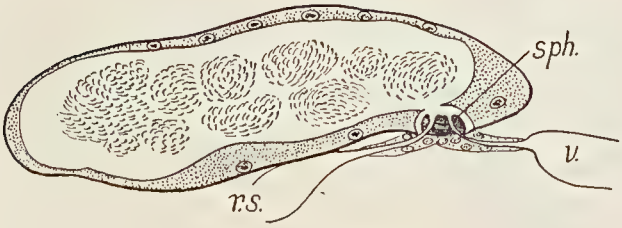

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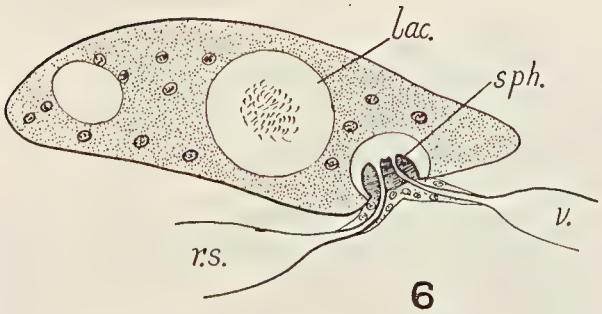

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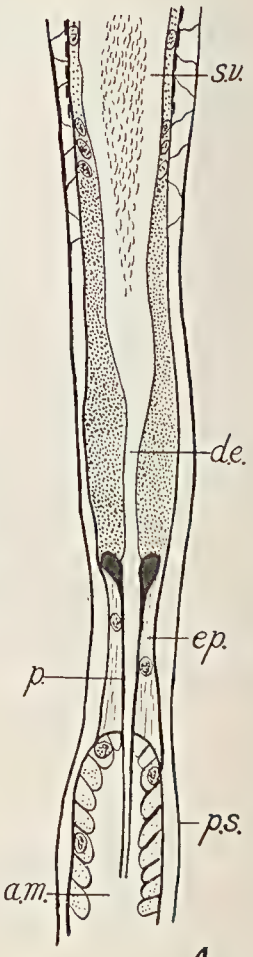

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Notothrix inquilina gen. et sp. nov.

FIG. 3.—Dorsal view of brain and main nerves.
FIG. 4.—Penis (stylet) in sheath.
FIL. 5.—Bursa copulatrix filled with many spermatozoa.
FIG. 6.—Bursa copulatrix with few spermatozoa.

surface. When removed from the intestine of its host and placed in sea water the Turbellarian creeps about with the wide rounded end directed forwards. It also swims freely with the body somewhat twisted or with the concave ventral side uppermost. If several individuals are placed together in a dish they will often become attached to one another by means of the strong suctorial pharynx and are then difficult to separate without damage.

In order to examine the internal features specimens were fixed in either Bouin's fluid or in sublimate-acetic. Sections were cut at 5-10 μ and stained in haematoxylin and eosin.

Body epithelium: The cells of the dorsal surface are ciliated. In horizontal sections they appear polygonal, usually six-sided. In longitudinal sections they appear rectangular and usually columnar. They vary in height from 7-12 μ and in width from 7-27 μ according to the degree of contraction or extension of the animal. The nuclei of the cells are about 6 μ in diameter and the cilia 4 μ in length.

The cells of the ventral surface are non-ciliated and form an epithelium which is thinner than that of the dorsal surface. In height the cells vary from 6-7 μ and in width from 10-14 μ. Their nuclei are slightly smaller than those of the dorsal cells. Both dorsal and ventral epithelia are devoid of gland cells, rhabdites and pigment.

Body musculature: The muscular sheath lying below the body epithelium consists of an outer layer of transverse fibres and an inner layer of longitudinal fibres. Between the two layers are a few diagonal muscles. The transverse muscles are more numerous dorsally than they are ventrally, there being in a length of about 26 μ in the middle region of the body about 10 dorsal fibres and only 4 or 5 ventral fibres. The longitudinal muscles, on the other hand, are stronger and more numerous ventrally than dorsally. Some of the diagonal fibres arise from the sides of the longitudinal muscles. Dorso-ventral muscles are numerous. They are strongly developed lateral to the testes, where they pass upward between the testicular lobes.

Digestive system: The mouth is circular and in a median position on the ventral side of the body. In a specimen 1·11 mm. long it is 0·15 mm. from the front margin. It is opened by a series of radial fibres in the dermal muscular sheath and is closed by a sphincter. Immediately inside the mouth is a small pharyngeal pouch which leads into a large pharynx doliiformis, 0·135 mm. long and 0·129 mm. in diameter (fig. 2). The pharynx projects forwards and downwards from the front of the intestine. The usual pharyngeal muscles are present, namely, inner and outer circular, inner and outer longitudinal and radial. The inner circular muscles are stouter than the others and form about 29 rings. The epithelium lining the lumen of the pharynx consists of a layer of cells with distinct nuclei and is not merely composed of the extended ends of the cells surrounding the opening of the pharynx into the intestine. In the resting condition the cells measure 8 μ in height and their nuclei about 5 μ in diameter. They are non-ciliated and resemble the cells of the ventral surface of the body. Pharyngeal glands are absent. Arising from the antero-dorsal surface of the pharynx and passing upward to be inserted in the dorsal muscular sheath of the body are two pairs of strong retractor muscles. The first pair lie between the

pharynx and the brain. The second pair are a short distance behind the first pair and more widely separated. All four muscles have brush-like ends. Arising from the postero-ventral surface of the pharynx and passing backward close to the ventral body-wall are a number of stout longitudinal or slightly oblique fibres, which are inserted in the ventral dermal muscular sheath and which also act as retractors of the pharynx. Several protractor muscles arise on the front of the pharynx and pass forward and downward to be inserted in the ventral muscular sheath a short distance in front of the mouth.

The passage leading from the pharynx to the intestine is very short, measuring about 13 μ in length and 10 μ in width. Its wall is furnished with strong circular and longitudinal muscles, the latter being continued for some distance into the wall of the intestine. The circular muscles act as a strong sphincter closing the opening of the pharynx into the gut. The epithelium lining the passage consists of large pyriform cells some of which project into the lumen of the pharynx. A distinct oesophagus or " crop ", such as occurs in certain other species, is absent in the Turbellarian under consideration.

The intestine is an elongated more or less cylindrical sac extending backwards from the pharynx as far as the bursa copulatrix. The posterior end of the intestine usually overlies the anterior end of the bursa. The length of the intestine is about half that of the animal and varies from 0·589-0·786 mm. The width varies from 0·131-0·197 mm. There are no lateral diverticula. The cells lining the lumen of the gut are long and club-shaped. They contain numerous vacuoles, many of which enclose food particles. The vacuoles vary in diameter from about 10-21 μ. The cell nuclei are generally basal in position. The wall of the intestine is provided with a few weak longitudinal muscles but no circular muscles were observed. The sides of the gut are slightly indented by muscles which pass upward through the parenchyma from the ventral to the dorsal body-wall.

Excretory system: No special excretory organs were observed in either the living or the preserved specimens. It seems probable that excretion occurs at the general surface of the body.

Nervous system: The brain (fig. 3) is immediately in front of the pharynx and about 78 μ from the dorsal surface. It measures 70-86 μ in width. The main nerves arising from the brain are shown in fig. 3. Two pairs of short nerves are given off anteriorly and supply the front of the body. Behind these a large pair of nerves extend laterally giving branches to each side of the body in front of the pharynx. Posteriorly the brain gives rise to a pair of stout trunks, each of which soon divides to form a branch which extends in a postero-lateral direction to the sides of the body and a branch which runs round the pharynx to the ventral surface. The postero-lateral nerve gives off branches to the vitellaria, the testes and the dorsal surface.

Reproductive system: The atrium genitale commune is a somewhat narrow chamber lined with rounded or club-shaped non-ciliated cells. It curves upward to open at the genital aperture, the opening being closed by a sphincter. The atrium is provided with strong protractor

and retractor muscles and its outer wall is furnished with weak circular fibres and more strongly developed longitudinal fibres. Dorsally the atrium leads into the vagina. Below the vagina it communicates with the antrum masculinum and below the latter with the antrum femininum. Owing to the ductus communis joining the uterus near the atrium genitale, the antrum femininum is relatively short. Strong dorso-ventral muscles pass through the parenchyma on each side of the atrium.

The testes, which measure 550-655 μ in length and 118-131 μ in greatest width, are large, paired and slightly lobed. They lie one on each side below the vitellaria and extend from the pharynx almost to the posterior end of the ovaries.

The vasa deferentia measure about 131 μ long and 23 μ wide. Each arises from the inner side of the posterior half of the testis. In the resting condition the vasa deferentia converge below the intestine and above the bulbous part of the uterus (figs. 1 and 2). They unite and immediately join the anterior end of the seminal vesicle. When filled with spermatozoa they are very wide and thin walled.

The seminal vesicle is about 120-200 μ in length and 27-30 μ in diameter. Its wall is provided with strong circular and longitudinal muscles. The circular muscles form bands which are 1-6 μ in width. The seminal vesicle is lined with an epithelium of flat cells and is closed by a strong sphincter at its junction with the vasa deferentia. Posteriorly it narrows to form the ductus ejaculatorius. The latter measures 60-100 μ in length and about 13-15 μ in diameter. Its wall is provided with strong longitudinal and weak circular muscles. The lining of its lumen is thick and appears to consist of a protoplasmic syncytium.

At its posterior end the ductus ejaculatorius passes into the penis, which is a slender chitinous stylet, 47-54 μ in length, projecting into the antrum masculinum (fig. 4). When completely retracted the stylet is usually near the region of the shell-glands. However, it may protrude through the genital aperture, extend into the atrium, or occupy other positions in the posterior part of the male canal. The stylet rises from a strong circular base, which is about 8 μ in diameter and gives attachment to the longitudinal muscles of the ductus ejaculatorius. In transverse sections the ends of these muscles appear as 12 fibres arranged radially round the base of the stylet.

The germaria are elongate and paired. They lie one on each side of the body in the posterior third. Each is about 330-350 μ in length and is lobed posteriorly. The number of lobes varies from two to three and sometimes differs in the left and right germaria of the same specimen. Anteriorly the germaria curve inwards and open laterally into the ductus communis immediately behind the openings of the vitellaria.

The vitellaria (fig. 1) occupy the middle two-thirds of the body. They are paired and dendritic, with four to ten main branches on each side (Plate I, figs. 1 and 2). The branches extend laterally above the testes and often divide dichotomously. The two median stems, however, lie below or at the sides of the intestine. The ends of the most anterior branches are level with the front of the pharynx, whilst the ends of the posterior branches lie lateral to and almost level with the posterior ends of the germaria. The left and right vitellaria are often asymmetrical,

there being more branches on one side than on the other. They converge in front of the germaria and open directly into the anterior end of the ductus communis.

The ductus communis is 250-390 μ in length. It lies immediately below the receptaculum seminis and, for the greater part of its length, above the male canal. It extends from the convergence of the vitellaria almost to the atrium genitale. Before reaching the latter, however, it curves downwards on the right side of the antrum masculinum to open into the neck of the uterus (uterine duct). From its junction with the germaria to a position below the middle of the receptaculum seminis the ductus communis is a narrow tube having a diameter of about 6 μ. It then suddenly increases in diameter to about 24 μ. Into the anterior end of this wider part open the so-called shell-glands. These glands form two large groups of elongate pyriform cells situated behind and between the germaria. They extend forwards surrounding the male canal and open into the ductus communis ventrally and laterally (Plate I, fig. 3). The outer wall of the ductus communis is provided with weak circular and stronger longitudinal muscles. The wide part of the duct is lined with rounded or club-shaped cells, the narrow part with flat cells. At its opening into the uterine duct the ductus communis is surrounded by a sphincter.

The uterus lies in a median ventral position and extends from the atrium commune almost to the pharynx. The anterior part is ovoid, somewhat dorso-ventrally compressed and measures 219 μ in length, 87-92 μ in height and 132-137 μ in width. Posteriorly the ovoid part merges into a long neck or uterine duct, 342 μ long, 13 μ high and 50-76 μ wide, which extends backwards to the atrium. Before entering the latter, however, it curves upward and is joined by the ductus communis. The uterus is lined by an epithelium of flattened cells and its outer wall is provided with circular and longitudinal muscles.

Only a single egg-capsule is present in the uterus at one time. It is yellowish in colour, ovoid in shape and with one end drawn out into a long slender much coiled filament, which rests in the posterior elongated neck of the uterus (Plate II, fig. 7). The ovoid part of the capsule measures 189-210 μ long and 97-137 μ in diameter. Its wall is of a horny or chitinous nature and measures 5 μ in thickness.

The vagina is about 81 μ in length. It leads directly from the dorsal part of the atrium to the bursa copulatrix (fig. 2). On leaving the atrium it has the form of a wide tube about 45 μ long and 21 μ in diameter. This tube is lined with club-shaped cells and its outer wall is provided with circular and longitudinal muscles. Anteriorly the vagina becomes reduced to a narrow duct about 36 μ long and only 3 μ in diameter. The lining of this narrow part of the vagina appears to be cuticularized. The duct enters the bursa copulatrix ventrally a short distance in front of the posterior end of the latter. At the point of entry it passes through a hemispherical structure, 21 μ in diameter, which projects into a lacunar space in the bursa (figs. 5 and 6).

The bursa copulatrix has the form of a long ovoid or spindle-shaped sac measuring about 165-186 μ in length and 60-75 μ in width. It lies between the germaria and near the dorsal surface. Its anterior end,

however, underlies the posterior end of the intestine. The wall of the bursa is glandular and has the appearance of a protoplasmic syncytium with irregularly disposed nuclei. Spermatozoa contained within the bursa form rounded masses. When these are numerous the wall of the bursa is relatively thin and the lumen large (fig. 5), but when the masses of spermatozoa are small and few, the wall becomes so thick that the lumen is reduced to lacunar spaces in a syncytial mass (fig. 6 and Plate II, fig. 6). The outer wall of the bursa copulatrix is furnished with very fine circular and longitudinal fibres.

Immediately in front of the entrance of the vagina into the bursa and passing through the same dome-like structure is a narrow duct directed downwards and forwards. The duct soon expands to form an ovoid or spindle shaped sac, the receptaculum seminis, which lies close below the bursa (fig. 2) and extends forwards and downwards to open into the ductus communis above the junction of the latter with the germaria. The length of the receptaculum is about 200 μ. Its diameter depends on the extent to which it is filled with spermatozoa and may vary from 36-72 μ. The epithelium lining the receptaculum is composed of flat cells. Circular and longitudinal muscle fibres are present in the outer wall.

Habitat: Notothrix inquilina occurs in the intestine of *Mensamaria thomsoni* (Hutton) and is usually found in the pigmented first part of the intestine. During the three months, January, February and March, 1954, one hundred and twenty-one specimens of the Holothurian were collected. Of these 51 were found to be infected with the parasite. Usually only one or two specimens of the Turbellarian were present in an infected host. In one case, however, 22 were found in the one Holothurian.

Locality: Fossil Island, Eaglehawk Neck, Tasmania.

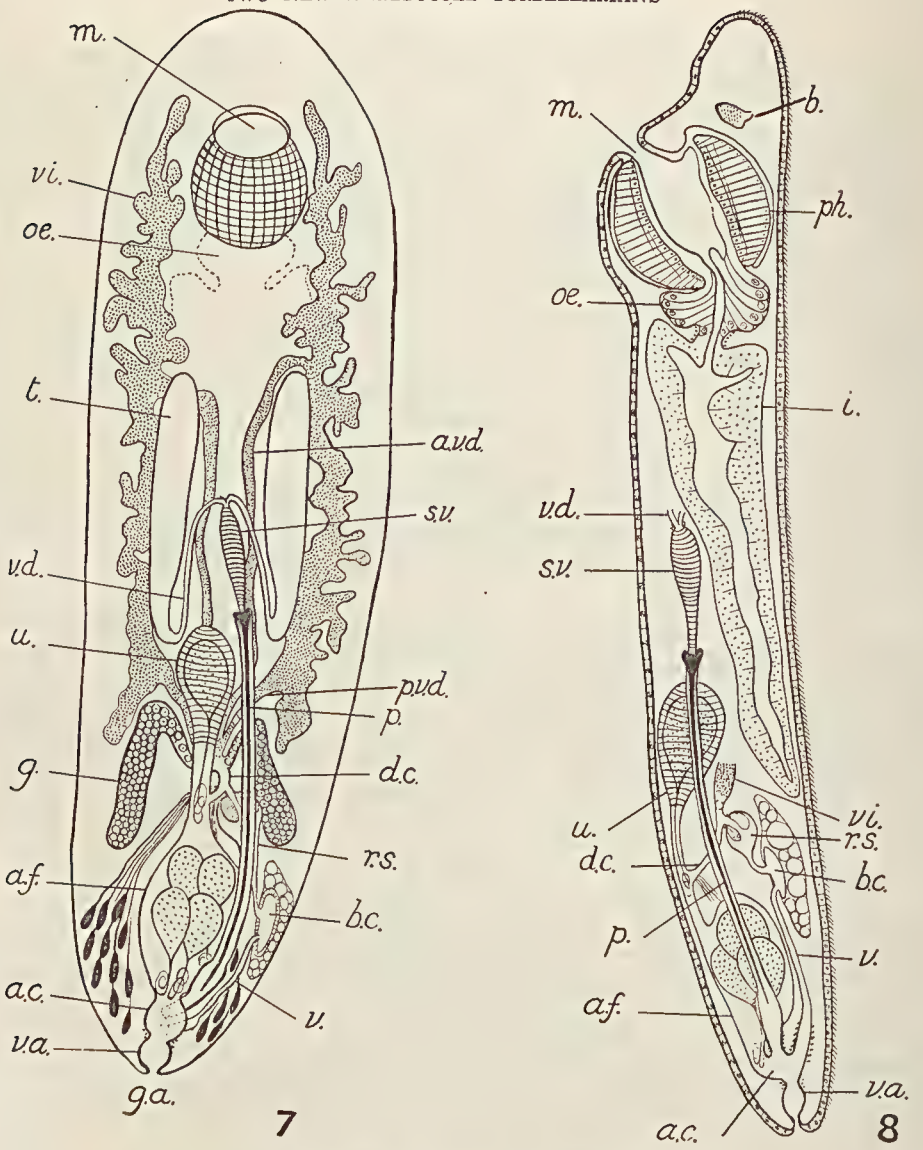
Affinities: Notothrix inquilina resembles *Wahlia macrostylifera* Westblad (1930), *Anoplodiera voluta* Westblad (1930) and *Monticellina longituba* Westblad (1953) and differs from all other recorded members of the family Umagillidae in having a non-ciliated ventral surface. It differs from *Wahlia macrostylifera* in possessing much larger testes and a glandular bursa copulatrix, from *Anoplodiera voluta* in having paired germaria and from *Monticellina longituba* in possessing much larger testes, a non-ciliated antrum masculinum and a not unusually long seminal vesicle.

Genus: *Ozametra* Marcus, 1949

(Syn. *Xenometra* Ozaki, 1932)

Definition of genus: Umagillidae with the uterus composed of two parts: an anterior ovoid primary uterus connected by a narrow neck to a posterior sac-like secondary uterus (antrum femininum) containing several mature egg-capsules. Germaria paired, elongate, not lobed, situated in posterior third of body and directed backwards. Testes paired, lateral and in middle third of body.

Type of genus: *Xenometra arbora* Ozaki, 1932



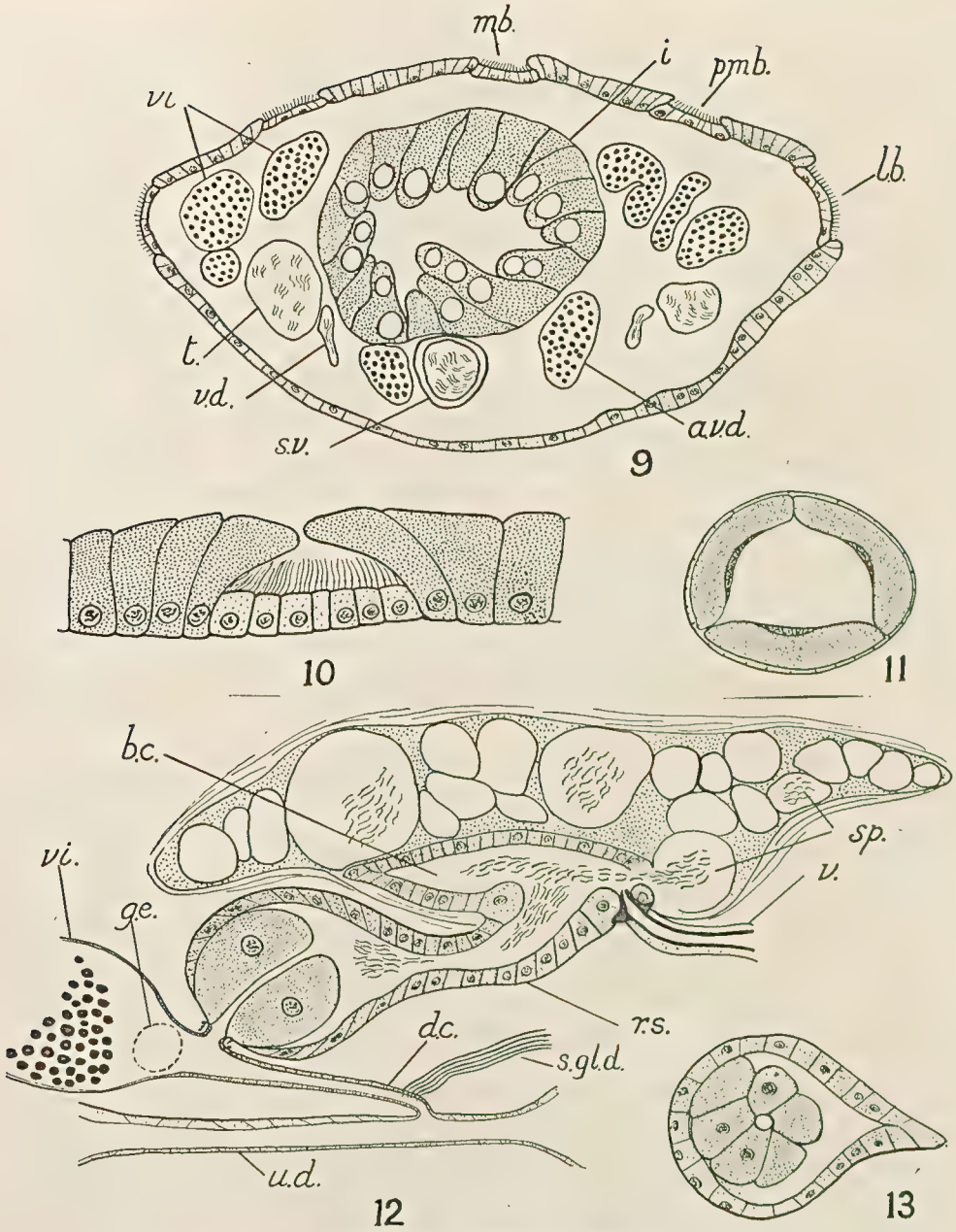
Ozametra striata sp. nov.

FIG. 7.—Ventral view of general organization.
FIG. 8.—Sagittal section.

Ozametra striata sp. nov.

(TEXT FIGURES 7-13. PLATE III)

External features: The body is leaf-shaped, rounded and wide in front, somewhat narrow posteriorly, convex above and flat or slightly convex below. It measures 1·48-1·96 mm. in length and 0·50-0·60 mm. in width. The mouth is in a median position on the ventral surface and about 1/9 of the animal's length from the anterior end. The genital aperture is at the posterior end (figs. 7 and 8).



Ozametra striata sp. nov.

FIG. 9.—Transverse section through body immediately in front of the uterus.

FIG. 10.—Transverse section through dorsomedian ciliated groove and adjacent epithelium showing the groove almost closed over.

FIG. 11.—Transverse section through anterior bulbous part of uterus.

FIG. 12.—Sagittal section through bursa copulatrix and receptaculum seminis.

FIG. 13.—Horizontal section through anterior wide part of receptaculum seminis.

The surface of the body is provided with five longitudinal ciliated bands, two of which extend along the lateral margins, one is mediodorsal, and one on each side is paramedian, being situated about midway between the mediodorsal and marginal bands (fig. 9). The width of the bands varies with the degree of extension or contraction of the animal. In a moderately extended specimen they are widest in the anterior quarter of the body. In this region the widths of the mediodorsal, paramedian and marginal bands are 90 μ, 51 μ and 39 μ respectively. The bands extend from the anterior to the posterior end of the body. The cells of the ciliated bands are about 5 μ whilst those of the adjacent epithelium are 10-13 μ in height. Hence, the bands appear to be in shallow grooves. In some cases the margins of a groove may be brought together so that the ciliated band is completely covered (fig. 10). The cilia are 5 μ in height and are confined to the cells forming the bands. All other epithelial cells of both dorsal and ventral surfaces are non-ciliated. The epithelium of the ventral surface is thinner than that of the dorsal surface. Rhabdites and pigment are absent.

The colour of the animal is whitish and translucent, the vitellaria and egg-capsules yellow.

Body musculature: Below the epithelial cells is a layer of transverse muscles and a layer of longitudinal muscles. Between the two are a few strong diagonal fibres (Plate III, fig. 8). The diameter of the diagonal fibres measures about 3 μ, that of the longitudinal fibres about 2 μ and that of the transverse fibres about 1 μ. On each side of the body is a series of dorsoventral muscles, there being about 19 such muscles on either side of the intestine.

Digestive system: The mouth leads into a large and strong pharynx doliiformis, which is situated at the anterior end of the alimentary canal and directed forwards and downwards. The pharynx measures about 189 μ in length and 199 μ in diameter. The usual muscles are present, the inner circular muscles being very strong and forming about 25 rings. The lumen of the pharynx is lined by extensions of the long club-shaped cells which form the lining of the oesophagus. The latter structure is situated between the pharynx and the intestine (fig. 8). In the contracted condition it measures 137 μ in diameter and 69 μ in length. Its outer wall is furnished with weak circular and strong longitudinal muscles. The opening of the oesophagus into the intestine is surrounded by a strong sphincter.

The intestine is an elongate sac about 655 μ in length and 158 μ in diameter. It lies in a median position close below the dorsal surface and extends from the oesophagus to the bursa copulatrix. The lumen of the intestine is lined by long club-shaped cells containing numerous vacuoles. The outer wall is provided with a few longitudinal muscles but no circular fibres can be seen.

Excretory system: As in the preceding species a specialized excretory system appears to be absent.

Nervous system: The brain lies immediately in front of the pharynx and about 44 μ from the dorsal surface. It measures 84 μ in width. As in the preceding species the main nerves given off from the brain consist

of three pairs of lateral nerves which run out to the sides of the body, and a pair of ventral nerves which pass round the sides of the pharynx.

Reproductive system: The atrium genitale commune (fig. 8 and Plate III, fig. 9) is large and constricted in the middle so that it forms two compartments, one in front of the other. The constriction between the two is surrounded by a sphincter. The posterior compartment is comparable to the vestibulum atrii, which occurs in certain other rhabdocoels. It is ovoid in shape, 53 μ long and 39 μ in diameter. It opens to the exterior by the genital aperture. The front compartment of the atrium leads anteriorly into the vagina above, the antrum masculinum in the middle and the antrum femininum below. All three apertures are surrounded by strong sphincters.

The epithelium lining both compartments of the atrium consists of club-shaped or pyriform cells. The outer wall is provided with circular and longitudinal muscles. Strong dilator muscles as well as protractor and retractor fibres arise from the sides of the atrium and extend outwards to the body wall.

The testes are paired. They lie one on each side of the intestine and below the vitellaria in the middle third of the body. Each measures about 406 μ in length and 52 μ in width, the length being slightly more than 1/4 that of the body. In shape the testes are somewhat cylindrical and without lobes. From the posterior end of each a thin-walled narrow vas deferens is given off. The two vasa deferentia turn inwards and forwards below the intestine. They converge at the anterior end of the seminal vesicle, into which they separately open.

In the retracted state the seminal vesicle lies in a median position below the intestine and immediately in front of the uterus (figs. 7 and 8). It is about 202 μ long and fusiform in shape, being 32 μ wide near its anterior end and tapering to 21 μ wide near its posterior end. Its outer wall is provided with strong wide circular muscles and weaker longitudinal fibres. Retractor muscles are attached to its front end. The lumen of the vesicle is lined by an epithelium of very flat cells. The posterior end of the organ opens into the base of the penis stylet.

In the largest specimens the stylet measures 720 μ long and is about 2/5 the length of the extended animal. It lies in a sheath, the wall of which is thin and furnished with fine longitudinal fibres. The stylet, which has a hard chitinous appearance, passes above or to the left of the anterior bulbous part of the uterus and extends almost to the atrium. Its base is expanded into a strong ring-like structure which has an external diameter of 16 μ and surrounds the posterior end of the seminal vesicle. The internal diameter of the stylet at the base is 5 μ but throughout the greater part of the length of the structure it is only 3 μ. The distal end of the stylet projects into the antrum masculinum. This region of the male canal is about 144 μ long and 16 μ in diameter. Its outer wall is provided with strong circular and longitudinal muscles and it is lined with slender club-shaped cells similar to those lining the atrium.

The germaria are paired and lie one on each side in the posterior third of the body. Each is about 500 μ long, more or less cylindrical and

not lobed. Anteriorly the germaria bend inwards and open into the ductus communis immediately behind the entrance of the vitelline ducts.

The vitellaria occur in the anterior two-thirds of the body. They form two irregular stems one on each side of the intestine. The stems give off short branches and extend from in front of the pharynx to the germaria. At about 3/7 of their length from the anterior end they give off on the inner side a pair of anterior vitelline ducts. These extend posteriorly below the intestine and unite with a pair of posterior vitelline ducts, which are given off a short distance in front of the posterior ends of the vitellaria. The two ducts thus formed converge in the mid-line and enter the anterior end of the ductus communis (fig. 7 and Plate III, fig. 10).

The ductus communis is very short varying from about 60 μ to 100 μ in length. It is wide anteriorly but decreases to about 18 μ near the middle of its length. Immediately behind the entrance of the vitelline ducts it is joined by the germaria, which open into it laterally. Slightly posterior to the junction with the germaria, but on the dorsal side, it is joined by the receptaculum seminis. From here it passes backward and downward to open dorsally into the neck of the uterus slightly in front of the antrum femininum. Near its junction with the neck of the uterus it receives the ducts from the shell-glands. These glands form two large groups of pyriform cells, one group on each side of the antrum femininum. The glands give rise to extremely fine ducts, which pass forward in two compact bundles to open into the ductus communis.

The uterus lies in a median position close to the ventral surface and extends from slightly in front of the convergence of the vitelline ducts to the atrium genitale. In an extended animal its length is about 1/3 that of the body. The anterior part is in the form of an ovoid or bulbous sac about 184 μ long and 53 μ in diameter. The cells lining the lumen of this part of the uterus are arranged in a series of rings, about 21 in number. Each ring consists of 3 curved cells placed end to end (fig. 11). The nucleus of each cell is closely applied to the inner wall of the cell. When the uterus is distended by the presence of an egg-capsule, the nuclei of the cells become so stretched that they are scarcely recognisable. Posteriorly the bulbous part of the uterus leads into a long somewhat depressed neck region or uterine duct, which is continued towards the atrium. Before reaching the atrium, however, the uterine duct expands into a large sac-like antrum femininum or secondary uterus, in which the egg-capsules are lodged prior to being discharged. The number of egg-capsules contained in the antrum femininum at one time varies from one to twelve. When filled with capsules the antrum may be so enlarged as to extend forwards almost to the convergence of the vitelline ducts, the adjacent organs being deformed and pushed out of position. The outer wall of the whole of the uterus is provided with circular and longitudinal muscles.

The egg-capsules (Plate III, fig. 11) are pyriform in shape, yellow in colour and chitinous in appearance. Each is produced into a long polar filament at one end. The bulbous part of the capsule is about 105 μ long and 78 μ wide and its wall is nearly 3 μ in thickness. When

the capsule is in the uterus the polar filament is closely coiled but after the capsule is discharged, the filament becomes uncoiled and straight. It then measures about 760 μ long and tapers to a very fine point. Numerous capsules massed together are often found in the cloaca and posterior part of the intestine of the host, *Stichopus mollis*. Sometimes they are drawn into the respiratory trees by the inhalent current and are lodged in the branches. A capsule contains two eggs. When the young are hatched they escape from the capsule at the wider end, where an operculum, 44 μ in diameter, is pushed off.

The receptaculum seminis (figs. 12 and 13) is pyriform in shape measuring 126 μ long and 60 μ in the diameter of its widest part. It leaves the bursa copulatrix ventrally a short distance in front of the entrance of the vagina. The lumen of the receptaculum is lined by columnar or cubical cells. In the narrow posterior part of the organ the cells are about 5 μ in height and their nuclei about 3 μ in diameter. However, the antero-ventral aperture of the receptaculum leading into the ductus communis is surrounded by six very large cells, which measure 39 μ in height and have nuclei 8 μ in diameter. These large cells project backward into the lumen of the receptaculum. Their cytoplasm is finely granular and they appear to be glandular in function. The outer wall of the receptaculum is provided with weak circular and longitudinal fibres. A sphincter surrounds the aperture leading to the ductus communis.

The bursa copulatrix (fig. 12) is a more or less spindle shaped sac, which measures 92μ long and 37 μ in diameter. Its lumen is lined with columnar cells rich in cytoplasm. Associated with the bursa and covering it dorsally and laterally are numerous large vacuoles or lacunae. Some of these contain spermatozoa and some also communicate with the cavity of the bursa. The parenchyma surrounding the bursa and vacuoles is fibrous in appearance. In its normal position the bursa lies immediately behind the intestine.

The vagina passes upwards and forwards from the dorsal wall of the atrium genitale. The posterior two-fifths of the vagina has a diameter of about 15 μ and is lined with club-shaped cells. Its outer wall is provided with circular and longitudinal muscles. The circular muscles become very large and strong towards the entrance of the vagina into the atrium. Anteriorly the vagina becomes a very narrow tube, which is only about 4 μ in diameter. The inner lining of this tube is cuticularized. It enters the bursa copulatrix ventrally a short distance in front of the posterior end of the latter. The entrance into the bursa passes through a papilla-like structure which stains very darkly with haematoxylin.

Habitat: Ozametra striata occurs in the first part of the intestine of its host, *Stichopus mollis* (Hutton).

Locality: D'Entrecasteaux Channel, Tasmania.

Affinities: Only two other species belonging to the genus *Ozametra* are known. These are *Ozametra arbora* (Ozaki) and *Ozametra elegans* Westblad. The new Tasmanian species, *Ozametra striata*, differs from *Ozametra arbora* in the position of the mouth, the relative size of the pharynx, the extent of the intestine, the form of the testes and penis and

in the nature of the bursa. It differs from *Ozametra elegans* in the form of the vitellaria, the relative size of the receptaculum seminis and in the sperm ducts arising from the posterior ends of the testes. It differs from both the species in possessing a vestibulum atrii and probably also in the peculiar ciliation of the body. However, it is not possible to make a definite comparison in respect to the latter feature, since the ciliation of the body in *Ozametra arbora* and in *Ozametra elegans* has not been described.

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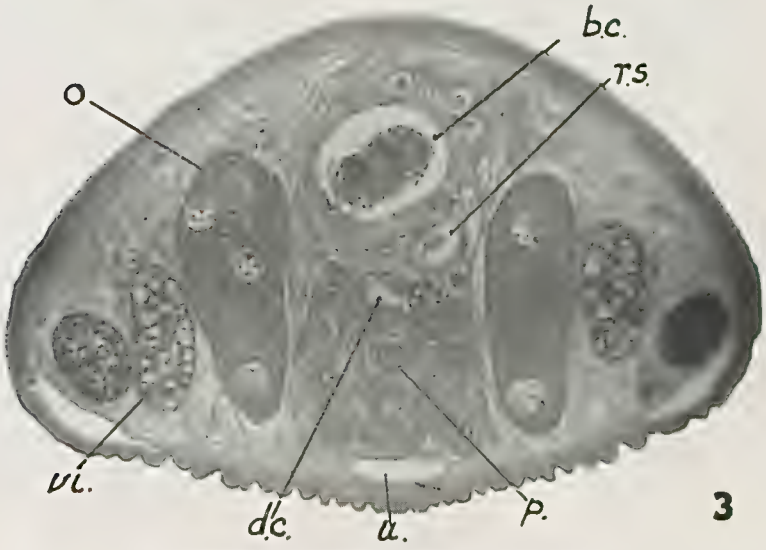
REFERENCES TO TEXT FIGURES AND PLATES

a.c.—Atrium genitale commune
a.f.—Antrum femininum
a.l.n.—Anterior lateral nerve
a.m.—Antrum masculinum
a.m.n.—Anterior median nerve
a.v.d.—Anterior vitelline duct
b.—Brain
b.c.—Bursa copulatrix
d.c.—Ductus communis
d.e.—Ductus ejaculatorius
e.p.—Epithelium of penis
g.—Germarium
g.a.—Genital aperture
g.e.—Entrance of germarium into ductus communis
i.—Intestine
lac.—Lacuna
l.b.—Lateral ciliated band
l.n.—Lateral nerve
m.—Mouth
m.b.—Median ciliated band
o.e.—Oesophagus
p.—Penis (stylet)
ph.—Pharynx
p.l.n.—Posterior lateral nerve
pm.b.—Paramedian ciliated band
p.s.—Penis sheath
p.v.d.—Posterior vitelline duct
r.s.—Receptaculum seminis
s.gl.—Shell glands
s.gl.d.—Shell gland ducts
sp.—Spermatozoa
sph.—Sphincter
s.v.—Seminal vesicle
t.—Testis
u.—Uterus
u.d.—Uterine duct (neck of uterus)
v.—Vagina
v.a.—Vestibulum atrii
v.d.—Vas deferens
vi.—Vitellaria
v.n.—Ventral nerve

Plate I

1

2



3

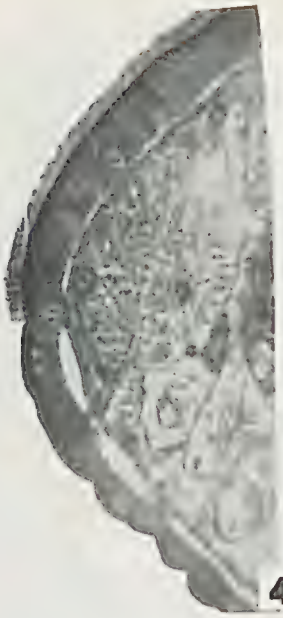
Notothrix inquilina gen. et sp. nov.

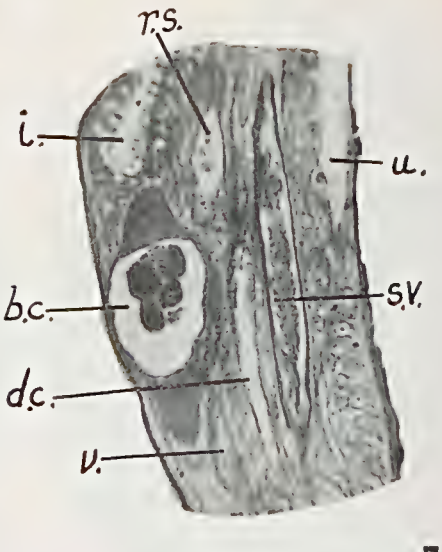
Fig. 1.—Whole mount, slightly compressed, stained in haematoxylin to show vitellaria. Egg-capsule has moved towards the posterior.

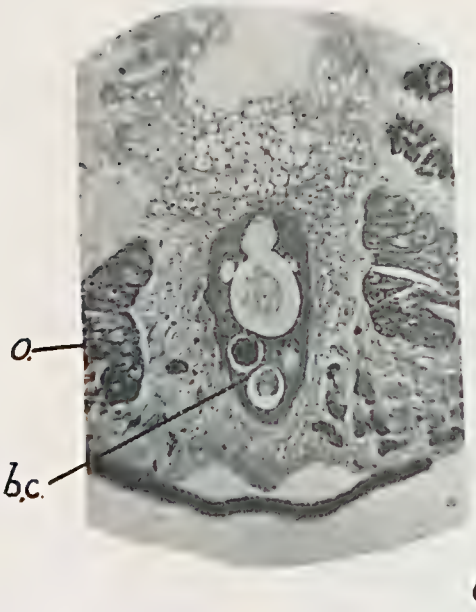
Fig. 2.—Whole mount, slightly compressed, stained in haematoxylin to show variation and asymmetry in the number of branches of the vitellaria. The egg-capsule has moved further towards the genital atrium than in the specimen shown in Fig. 1.

Fig. 3.—Transverse section through the body and passing through the middle of the bursa copulatrix.

Plate II







Notothrix inquilina gen. & sp. nov.

Fig. 4.—Transverse section through side of body showing the ciliated dorsal epithelium and the non-ciliated ventral epithelium.

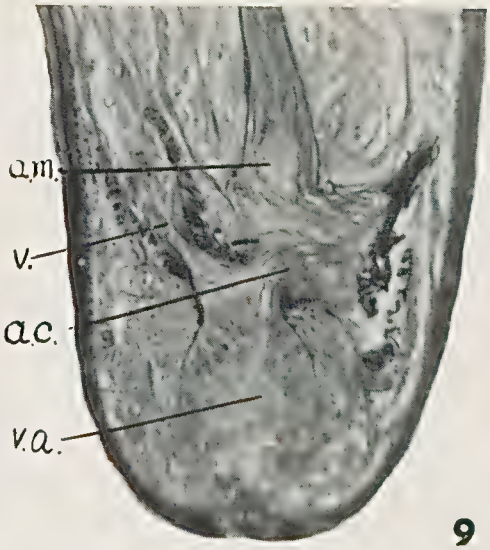
Fig. 5.—Part of a sagittal section through body in the region of the bursa copulatrix.

Fig. 6.—Horizontal section through bursa and adjacent structures, showing lacunae in the bursal syncytium.

Fig. 7.—Egg-capsule with its long coiled polar filament lying in the neck of the uterus.

Plate III

8



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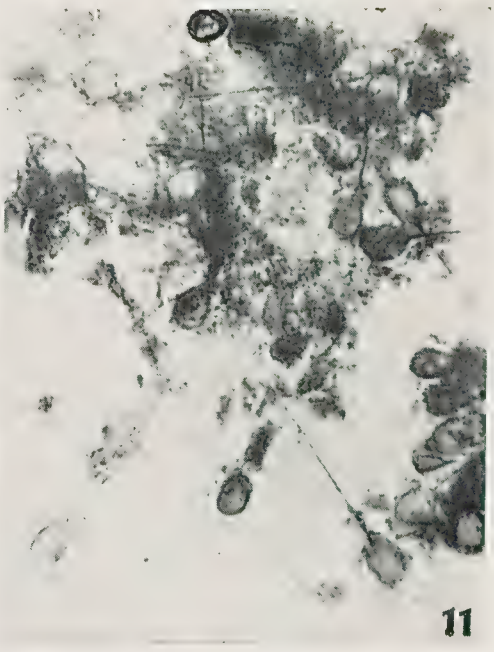

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Ozametra striata sp. nov.

Fig. 8.—Horizontal section through the sub-epidermal musculature showing the strong diagonal fibres.

Fig. 9.—Sagittal section through the posterior end of body showing the strong circular muscles round the end of the vagina.

Fig. 10.—Whole mount stained with alum carmine and showing the arrangement of the vitellaria.

Fig. 11.—Masses of egg-capsules of the Turbellarian mingled with material from the intestine of the host.

Arrangement of the female organs and ducts in the Cestode genera **Oochoristica** Lühe and **Linstowia** Zschokke

By

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(with 13 text figures)

Abstract

The different ways in which the female reproductive organs and ducts are arranged in ten species of *Oochoristica* Lühe and in three species of *Linstowia* Zschokke are discussed and compared.

In the species of *Oochoristica*, four modes, A, B, C and D, are recognized. *O. rostellata* Zschokke, *O. vacuolata* Hickman, *O. nyctophili* Hickman, *O. surinamensis* Cohn and *O. erinacei* Meggitt exhibit mode A; *O. trachysauri* (MacCallum), *O. mephitis* Skinker and *O. oklahomensis* Peery mode B; *O. scelopori* Voge and Fox mode C, and *O. lygosomae* Burt mode D.

The three species of *Linstowia*, namely, *L. echidnae* (Thompson), *L. semoni* (Zschokke) and *L. jheringi* Zschokke show three different arrangements. While the disposition of the organs and ducts in *L. echidnae* differs from that in any one of the ten species of *Oochoristica*, the arrangement in *L. semoni* resembles that in *O. trachysauri*, and the arrangement in *L. jheringi* is similar to that in *O. rostellata*.

Discrepancies in the descriptions of the three species *O. mephitis* Skinker, *O. pedunculata* Chandler and *O. wallacei* Chandler are noted.

Introduction

The descriptions of many species of *Oochoristica* Lühe are incomplete. Details of the female reproductive system are frequently omitted. In particular, descriptions of about 38 species contain little or no reference to the course of the female genital ducts, except the vagina.

The present paper is a review of the arrangement of the female organs and ducts in ten of the more adequately described species of *Oochoristica*. In addition, because of the close relationship between the genera *Oochoristica* and *Linstowia*, the arrangements in three species of the latter are discussed and compared with those found in the ten species of the former genus.

The Female Organs and Ducts in the Genus *Oochoristica*.

A study of the descriptions of the following ten species: *O. rostellata* Zschokke (1905), *O. vacuolata* Hickman (1954), *O. nyctophili* Hickman (1954), *O. surinamensis* Cohn (1903), *O. erinacei Meggitt* (1920), *O.*

trachysauri MacCallum (1921), *O. mephitis* Skinker (1935), *O. oklahomensis* Peery (1939), *O. scelopori* Voge and Fox (1950) and *O. lygosomae* Burt (1933), reveals four modes of arrangement of the female organs and ducts. The characteristic features of the four modes are given in the following table.

Character	Mode A	Mode B	Mode C	Mode D
Fertilization canal	Present	Present	Absent	Absent
Mehlis's gland (Shell gland)	Surrounds oviduct	Surrounds oviduct	Does not surround oviduct	Does not surround oviduct
Shell duct	Absent	Absent	Absent	Present
Uterine duct	Passes forwards dorsal to ovary. Enters uterus antero-ventral to ovary	Passes forwards dorsal to ovary Enters uterus antero-dorsal to ovary	Passes forwards ventral to ovary Enters uterus antero-ventral to ovary	Passes backwards dorsal to ovary Enters uterus dorsal to ovary
Species	*O. rostellata*, fig. 1 *O. vacuolata*, fig. 2 *O. nyctophili*, fig. 3 *O. surinamensis*, fig. 4 *O. erinacei*, figs. 5A & 5B	*O. trachysauri*, fig. 6 *O. mephitis*, fig. 7 *O. oklahomensis*, figs. 8A & 8B	*O. scelopori*, fig. 9	*O. lygosomae*, fig. 10

Of the cestodes listed as exhibiting mode A, the three species, *O. rostellata, O. vacuolata* and *O. nyctophili* have identically the same arrangement of the organs and ducts (fig. 1-3). The arrangement in *O. surinamensis* differs from that in those three species in that the vagina passes ventral, not dorsal, to the ovary (fig. 4). In *O. erinacei,* according to Meggitt (1920) both the vagina and the uterine duct pass ventral to the ovary. Moreover the uterine duct passes up in front of the ovary and enters the uterus antero-dorsal to this organ (fig. 5A). This arrangement is obviously the reverse of that in *O. rostellata, O. vacuolata* and *O. nyctophili.* It would appear, therefore, that Meggitt may have misinterpreted the orientation of his specimens and that the correct arrangement is that shown in fig. 5B.

The inclusion of *O. oklahomensis* among those species showing mode B requires explanation. Peery (1939) in the description of this species

states that the testes occur ventral to the ovary. However, when in cestodes, the testes occur in the same vertical plane as the ovary, they are always dorsal to this organ. Moreover, the arrangement of the female genital ducts in *O. oklahomensis* is obviously the reverse of that found in *O. trachysauri* (compare figs. 8A and 6). In view of these facts, it seems likely that Peery also may have mis-interpreted the orientation of his specimens and that the correct arrangement of the female genital organs and ducts is that shown in fig. 8B.

In reference to *O. scelopori* Voge and Fox, which exhibits mode C, it should be mentioned that in their description of this species, the authors do not state the position of the genital ducts relative to the ovary. In their fig. 5, p. 240, they show the vagina passing above and the uterine duct passing below this organ. However, they do not state whether the figure represents a dorsal or a ventral view. Assuming that it is a dorsal view, then the arrangement of the female organs and ducts in this species is that shown in fig. 9.

Now, in modes A and B, the vagina and vitelline duct do not enter the oviduct at the same place. The region of the oviduct between the entrance of the vagina and the entrance of the vitelline duct is recognised as the fertilization canal. In C and D the vagina and vitelline ducts both enter the oviduct at the same place. Thus, a fertilization canal is absent. In C, the two ducts enter the oviduct posterior to the ovarian bridge, whilst in D, they enter the oviduct at the ovarian bridge.

In A and B, Mehlis's gland lies antero-dorsal to the vitelline gland and surrounds the oviduct near or at its union with the vitelline duct. A shell duct is absent. In C, also, Mehlis's gland lies antero-dorsal to the vitelline gland, but does not surround the oviduct. Instead it apparently surrounds a cavity which opens into the vitelline duct. The vitelline duct therefore conveys to the oviduct the products of both the vitelline gland and Mehlis's gland. A distinct shell duct is absent. In D, Mehlis's gland lies dorsal to the vitelline gland and does not surround the oviduct. A narrow duct, the shell duct, passes forwards from Mehlis's gland and enters the oviduct at the ovarian bridge.

In A and B the uterine duct arises from the ootype antero-dorsal to the vitelline gland, and passes forwards dorsal to the ovary. In A, it then bends and passes down in front of the ovary to enter the uterus antero-ventral to this organ. In B, however, it does not pass down in front of the ovary, but instead opens into the uterus antero-dorsal to this organ. In C, the uterine duct arises from the union of the oviduct, vitelline duct and vagina. This union occurs postero-ventral to the ovary. The uterine duct then passes forwards below the ovary and enters the uterus antero-ventral to the ovary. In D, the uterine duct arises from the ootype at the ovarian bridge and passes back dorsal to the ovary where it enters the uterus.

The Female Organs and Ducts in the Genus *Linstowia*.

The descriptions of three species of *Linstowia*, namely, *Linstowia echidnae* (Thompson), *Linstowia semoni* (Zschokke) and *Linstowia jheringi* (Zschokke), include details of the arrangement of the female organs and ducts.

In *Linstowia echidnae,* the type of the genus, the disposition is shown in figure 11. On comparing it with the four modes of arrangement in the genus *Oochoristica* it is seen to resemble mode A. However, in *Linstowia echidnae,* the uterine duct, instead of passing forwards above the ovary, passes downwards between the ovary and vitelline gland. Moreover, it enters the uterus not antero-ventral to the ovary but antero-ventral to the vitelline gland.

In *L. semoni,* the arrangement is that shown in figure 12. It differs from that in *L. echidnae* in that the uterine duct passes forwards dorsal to the ovary and enters the uterus antero-dorsal to this organ. A comparison with the four modes in the genus *Oochoristica,* reveals a striking resemblance to mode B.

The disposition of the organs and ducts in *L. jheringi* is shown in figure 13. It differs from that in *L. echidnae* in the uterine duct passing forwards dorsal to the ovary and from that in *L. semoni* in the uterine duct entering the uterus antero-ventrally to the ovary. Furthermore, the arrangement in *L. jheringi* resembles mode A in the genus *Oochoristica.*

López-Neyra (1954, p. 241, 245) has emended the diagnosis of the genera *Linstowia* and *Oochoristica* and has transferred eight species of *Oochoristica* into the genus *Linstowia.* Those species, in which the cirrus pouch is large and extends into the medulla beyond the poral longitudinal excretory vessels, almost to the middle of the segment or even as far as the aporal vessels, he includes in the genus *Linstowia.* The species, in which the cirrus pouch is not large and reaches or just passes the level of the poral excretory vessels, he places in the genus *Oochoristica.* This classification would appear unsatisfactory since it groups together species which have markedly different arrangements of the genital organs and ducts.

It would seem that the two genera, *Oochoristica* and *Linstowia* are each heterogeneous and require division into several genera. When details of the disposition of the female organs in the type of the genus *Oochoristica,* namely, *O. tuberculata,* and in other species of both genera, are available, a more satisfactory classification will be possible.

In the course of the present study the writer noticed some lack of agreement between text and figures in the descriptions of the three species, *O. mephitis,* Skinker, *O. wallacei* Chandler and *O. pedunculata* Chandler.

Skinker (1935, p. 61) in her description of *O. mephitis* states, "vas deferens . . ., passing along the middle of ventral surface of ovary", and "Seminal receptacle conspicuous, . . . dorsal to poral lobe of ovary". However, in figure 3, p. 61, she shows the vas deferens passing along the same surface as does the vagina.

In his description of *O. wallacei,* Chandler (1952, p. 69) remarks: "seminal receptacle always dorsal to third excretory vessel". However, in fig. 1, on page 70, the seminal receptacle is shown ventral to the third excretory vessel. Again, in describing *O. pedunculata,* he states on page 72: "Testes . . . situated laterally and posteriorly to ovary

and vitellaria, occasionally a few dorsal to these glands" and on page 73: "seminal vesicle . . . dorsal to poral side of ovary". However, in fig. 5, p. 72, a few testes are seen lying ventral to the ovary and vitellaria. Furthermore, in the same figure the seminal vesicle (actually the receptaculum) is shown ventral to the poral side of the ovary.

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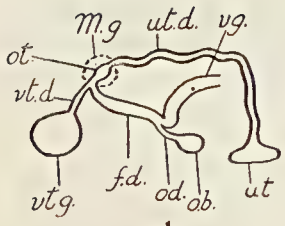

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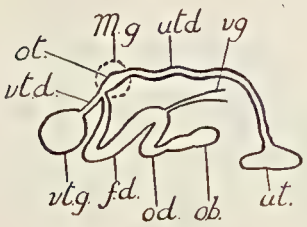

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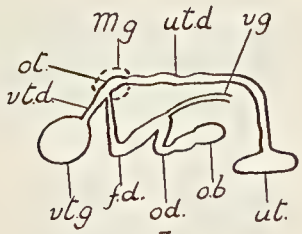

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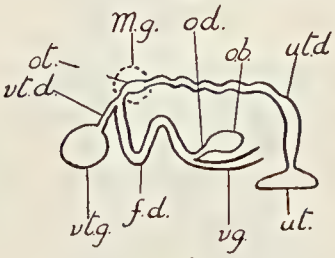

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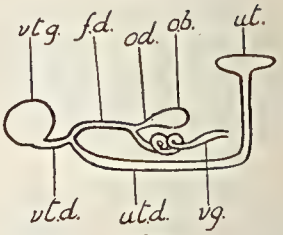

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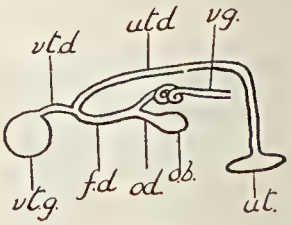

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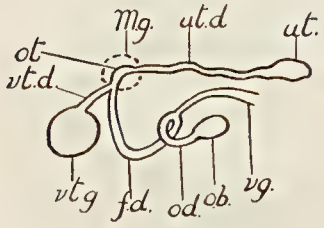

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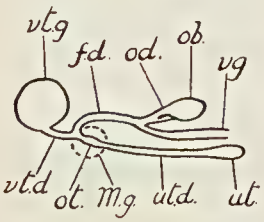

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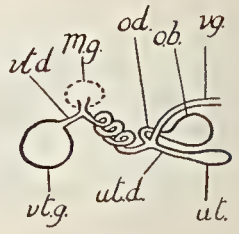

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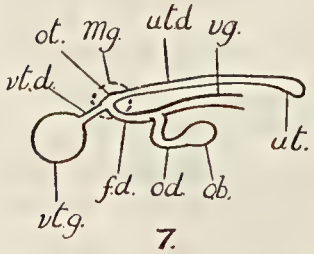

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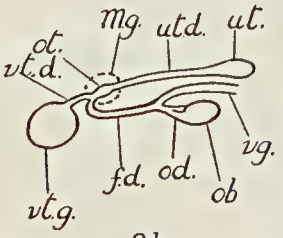

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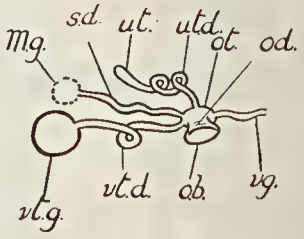

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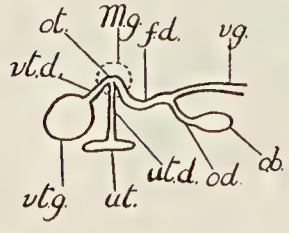

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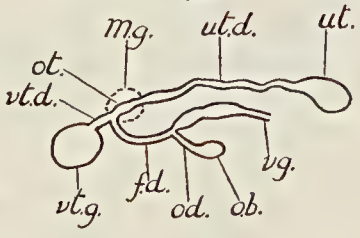

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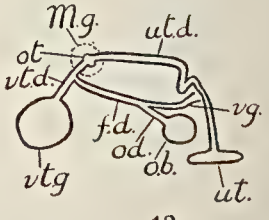


13.

References to Figures

f.d.—fertilization canal
M.g.—Mehlis's gland.
o.b.—ovarian bridge.
od.—oviduct.
ot.—ootype.
ov.—ovary.
s.d.—shell duct.
ut.—uterus.
ut.d.—uterine duct.
vg.—vagina.
vt.d.—vitelline duct.
vt.g.—vitelline gland.

Explanation of Figures 1-13

Each figure is a diagrammatic representation of a sagittal section of a mature proglottis. Only the relationship of the female genital ducts to the ovary, vitelline gland, Mehlis's gland and uterus is shown.

Fig. 1.—*Oochoristica rostellata* Zschokke (1905) based on original description and figure.
Fig. 2.—*O. vacuolata* Hickman (1954) as in type specimen.
Fig. 3.—*O. nyctophili* Hickman (1954) as in type specimen.
Fig. 4.—*O. surinamensis* Cohn (1903) based on original description and figure.
Fig. 5A.—*O. erinacei* Meggitt (1920) based on original description.
Fig. 5B.—*idem.*, reorientated as suggested in present paper.
Fig. 6.—*O. trachysauri* (MacCallum, 1921) based on description and figure given by Johnston (1932).
Fig. 7.—*O. mephitis* Skinker (1935) based on original description and figure.
Fig. 8A.—*O. oklahomensis* Peery (1939) based on original description and figure.
Fig. 8B.—*idem*, reorientated as suggested in present paper.
Fig. 9.—*O. scelopori* Voge and Fox (1950) based on original description and figure.
Fig. 10.—*O. lygosomae* Burt (1933) based on original description and figure.
Fig. 11.—*Linstowia echidnae* (Thompson, 1893) based on description by Zschokke (1898) and description and figure by Kerr (1935).
Fig. 12.—*L. semoni* (Zschokke, 1896) based on description and figure by Zschokke (1898).
Fig. 13.—*L. jheringi* Zschokke (1904) based on original description and figure.

Jorgensen's Journey Across the Central Plateau—September-October 1826

From the papers of the late

A. L. Meston, M.A.

(*Edited by W. Meston and R. A. V. McCulloch*)

Introduction

These notes have been extracted from the mass of Mr. Meston's unpublished papers and represent the skeleton of a monograph on Jorgensen's explorations which was under preparation during the years immediately before his death.

The patient unravelling of Jorgensen's contradictory and often apocryphal reports against the test of actual country and weather conditions, and the reconstruction of his routes and camping-places, occupied the sparse leisure of many years and some hundreds of miles of walking.

One of these recurrent problems was Jorgensen's 1826 journey from Hobart across the Central Plateau, undertaken for the V.D.L. Co. in conjunction with Hellyer's expedition from the N.W. Coast, both designed to open a route across country to the West and North-West Coasts, and also in search of possible grazing ground within the terms of the V.D.L. Co.'s charter.

Jorgensen's Report claimed that he had reached the landmark then known as the "Peak like a Volcano" (which was named St. Valentine's Peak in the following February by Hellyer) and also the lake which he described as the source of the Derwent. He named Mt. Dundas and the Parsons's Hood, and believed that his circular route had taken him within a few miles of the Frenchman's Cap and the mouth of the Pieman River. All quite irreconcilable with the actual time and distance of the adventure.

These statements were for many years repeated as uncritically as a medieval transcript, and Jorgensen has been given the credit of discovering Lake St. Clair on the strength of his identification of the Derwent, and also of having preceded Hellyer in the Surrey Hills and Middlesex Plains area.

Alternatively, since no stretch of imagination can reconcile Jorgensen's report with the country he imagined himself to be traversing and the time he allowed himself for the exploit, the whole account has been written off as a fabrication.

Mr. Meston supported a part of the first interpretation in a paper read before the A.N.Z.A.A.S. conference of 1928, but after detailed and exhaustive investigation of the country he altered his conclusion, for he found it possible to identify Jorgensen's landmarks and descriptions under actual conditions of country and weather, reducing the irreconcilable distances and the conflicting ascriptions to a possible and quite creditable piece of exploration.

Points to be clarified were: first, the identification of the mountain which Jorgensen believed to be Flinders' "Peak like a Volcano", the lake beneath it from which two rivers flowed, the several mountains on which he orientated his positions, and the exact point from which he took his bearings: secondly, his crossing-place of the Ouse, the rock which deflected his compass, and the verification of his minor details of geological description, occurrence of "cyder" gums and "pine" trees, and other aspects of country.

Mr. Meston's conclusions were that Jorgensen never saw the Frenchman's Cap and never left the Plateau; that he reached neither Lake St. Clair nor St. Valentine's Peak, his "Peak like a Volcano" being identifiable as the highest point of the plateau, the Western Wall of Jerusalem, his "bottomless gulph" as the Gorge of the Mersey, and his lake that which Mr. Meston recorded in 1941 as "Lake Barbara",

directly below the complex of the Walls; that the place where he took his bearings is now known as the Big Hill near Liawenee, that he crossed the Ouse a little above the junction of the James River, and the camp where his compass failed him was at Little Split Rock.

The field-work for these conclusions was done in several trips, in 1927, accompanied by Professor King, in 1941, with N. J. B. Plomley, and in 1945, '46, and '48 with R. A. V. McCulloch. Little or no accurate surveying of the higher country had then been done, so that much of the work consisted of fixing positions, bearings, and cross-bearings, and of checking visibility. The work of the Aerial Survey and the H.E.C. has since covered the area and simplified problems which were formerly solved by intersecting observations from points as far separated as Cradle Mountain, Mt. Rufus, and Mt. Field.

Part of the country over which Jorgensen struggled has now fallen under the H.E.C.'s scheme. The new dam across the Ouse will drown several miles of hollow moor and obliterate the course and junction of the Ouse and the James Rivers where both men, over a century apart, but facing the same conditions, found each the same crossing place and were thrown by the condition of the country upon nearly identical camping grounds.

Jorgensen's Journey Across the Central Plateau—1826

Introductory Notes

Jorgensen had spent only three months in Van Diemen's land when he received, through the London influence of Mr. Dundas, employment with the Van Diemen's Land Company as explorer and surveyor.

His 1826 expedition from Hobart to the Central Plateau was intended to open a stock-route from the settled areas of the Clyde and the Derwent to the Company's holdings on the North-West Coast, and possibly to find a practicable approach to the West Coast. He was expected to meet Hellyer and his party somewhere in the no-man's land between the Great Lake and Valentine's Peak, and Thomas Scott's "Chart of Van Diemen's Land" (1824) illustrates the undertaking of both these men. (See chart facing page 110.)

In the blank space on which Jorgensen launched himself, two landmarks stand out by general familiarity and reasonably accurate location—the Frenchman's Cap, and Flinders' "Peak like a Volcano", so described in Scott's Chart, and later named Valentine's Peak by Hellyer on February 1, 1827. It is to be remembered that no one had yet seen either of these mountains from the angle whence Jorgensen approached them.

In summary, Jorgensen left Hobart on September 2nd for "Dr. Ross's Farm" on the Shannon (the Hermitage), having with him Mark Logan and Andrew Colbert, "a black man". They carried knapsacks, but expected to live mainly on kangaroo, and took two dogs for hunting. On September 11th, they were 16 miles further on at Patrick Plains, in bad weather, where there was a stockkeeper's hut. From the 16th to the 20th they were unable to cross the Shannon there and Logan went back to Patterson's farm (3 miles above the Hermitage) for more provisions.

On September 21st in fine weather they crossed the Shannon and made camp that night on the South-West corner of the Great Lake.

On the 22nd they were stopped by the Ouse, which at the time Jorgensen was inclined to identify as the Derwent, and camped in the bush a little back from the river.

The 23rd was still wet and the river still unfordable seven miles up where the river made a westerly bend and approached the foot of a snow-covered mountain.

The 24th was fine. Again following the east bank of the river they advanced two miles further (i.e., nine from last camp), found the river returned to its northerly course and poured between two stupendous rocks. They built a hut on a high hill. From here Jorgensen took his latitude 41° 52′, approximately the position of Liawenee) and recorded bearings of "Frenchman's Cap", "Table Mtn.", "Mt. Dundas", and Parson's Hood". In wet and stormy weather the party retreated to civilisation, returning to Patrick's Plains on the 28th, and the Hermitage on the 29th.

On the 30th Logan returned to Hobart with a provisional report from Jorgensen.

On October 11th the party again set out from Patterson's hut, reaching the Ouse (near Skittleballs) on the 18th and camping again in the hut they had previously built at Liawenee. Following up the east bank of the Ouse on the 20th, they found the first practicable fording place above the junction of the James River, and slept that night under Little Split Rock. Here the compass was deflected, but Jorgensen for the first time records a bearing on the "Peak like a Volcano" (i.e., the West Wall.

On the 21st they set out, West by North, for the Peak, crossed the James with difficulty (a little below Lake Pillan), were much impeded by lagoons and basins of water and saw pines growing.

On the 22nd they reached the southern side of the Peak which was too deeply covered with snow to be climbable. The country was high, rocky, and desolate, the trees small and scanty. Proceeding westward they were obstructed by a river flowing North and South and rising from a large lake between the summit of the Peak and the main mountain mass on which they stood. Their way was barred by "a chasm many miles in width, to the view a bottomless gulph".

On the 23rd, still trying to skirt the lake, in bad weather, they recorded a second river, broad and rapid, flowing from it towards the S.S. West. This Jorgensen concluded to be the source of the Derwent.

On the 24th, the third day of snow and fog, they retreated toward lower country, keeping as far westward as possible towards the mountains Jorgensen had named Dundas and Parson's Hood. He believed that the Derwent, as he considered it, effectively barred his approach to them and held a southerly course.

By the 25th they had reached good grazing country, abounding in timber and plentiful in fat kangaroos.

On the evening of the 26th they camped by a lake nearly as large as the Great Lake, which Jorgensen believed to be Lake Fergus, but he describes it as being sheltered from the North by a series of amphitheatres and lofty forest.

Walking, on the 27th, over good grazing country, they saw the tracks of wild cattle and native huts, and found themselves within sight of the tableland of the Clyde and the two Sugar Loafs near Shannon Point, concluding therefore that they must be within forty miles of habitation. They reached Hobart by way of New Norfolk on the 1st of November.

In making his report Jorgensen concluded that he had "explored the whole of the country marked 'unknown' in Scott's map situated eastward of that range of mountains" (23rd inst.) which he identified with Flinders' "Peak like a Volcano", that he reached the outlying spurs of the Peak before he was finally blocked by the bottomless gulf beyond which he considered human endeavour could not penetrate; and that the upper course of the Derwent was drawn from the lake he found lying below the Peak. He believed that he had approached within 15 miles of the Frenchman's Cap and within 20 miles of the mouth of the Pieman, and that "a road for sheep and cattle may certainly be traced immediately to the Southward of Mt. Dundas to the Pieman River and Cape Grim". He had named the moor west of the Great Lake "Arthur's Plains" and had sighted and named two high mountains, "Mt. Dundas and the "Parson's Hood".

The following account is given in Jorgensen's own words, condensed from his daily Journal and from his final Report.

Of the Journal only a fragment exists. It was given by himself to Mr. George Scott at Mount Moriston near Ross while he was lodging there in 1828 or '29. It lay there unregarded in the kitchen and the remainder "was torn out by the convict servants to light pipes", but the existing portion carries the conviction of fresh experience.

The Report is dated November 8th and varies slightly from the journal in places while in his later writings other variations of a well-told tale creep in. As Roberts admits, there is the possibility that Jorgensen lied—"in fact this would be the normal thing for him to do". But where rock, stream and watershed remain in corroborative evidence, his statements may reasonably be accepted.

Thanks must be recorded to the Mitchell Library for permission to quote Report and Journal in extenso.

REPORT BY JORGEN JORGENSEN OF A JOURNEY UNDERTAKEN FOR DISCOVERY OF A PRACTICABLE ROUTE FROM HOBART TOWN TO CIRCULAR HEAD—NOVEMBER 8, 1826.

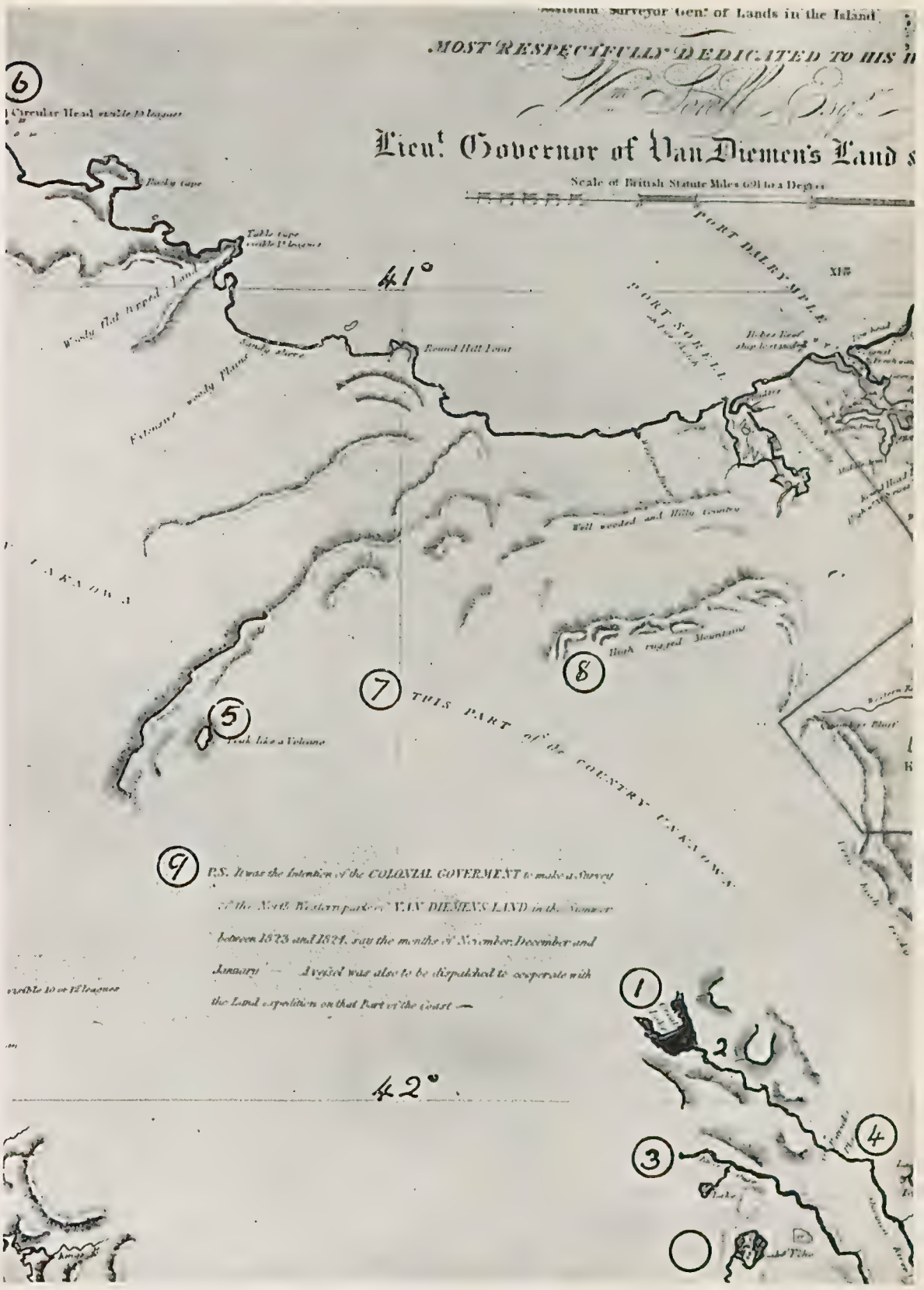
(*Extract from Van Diemen's Land Co.'s Report*, 1828)

SIR,

On the 2nd September Mark Logan, Andrew Colbert (a black man) and myself departed from Hobart Town and conformably to the instructions you supplied me with we proceeded direct to Mr. Ross' farm on the Shannon where we arrived on the 6th.

Section of the "*Chart of Van Diemen's Land*", 1824, by Thomas Scott.
(*Reproduced by courtesy of the Tasmanian Museum.*)

(1) Great Lake
(2) Shannon River
(3) River Ouse
(4) St. Patrick's Plains
(5) "Peak Like a Volcano"
(6) "Circular Head visible 10 leagues"
(7) "This part of the Country Unknown"
(8) "High rugged mountains"
(9) "P.S. It was the intention of the COLONIAL GOVERNMENT to make a Survey of the North-Western part of Van Diemen's Land in the Summer between 1823 and 1824, say, the months of November, December, and January. A vessel was also to be despatched to co-operate with the land expedition on that part of the Coast . . .".


Surveyor Gen.l of Lands in the Island
MOST RESPECTFULLY DEDICATED TO HIS
Lieut. Governor of Van Diemen's Land
Scale of British Statute Miles 691 to a Degree
Circular Head visible 10 leagues
Rocky Cape
Table Cape visible 12 leagues
Woody flat tipped Land
Sandy shore
Extensive woody Plains
Round Hill Point
PORT DALRYMPLE
PORT SORELL
Well wooded and Hilly Country
High rugged Mountains
Peak like a Volcano
THIS PART of the COUNTRY UNKNOWN
P.S. It was the Intention of the COLONIAL GOVERMENT to make a Survey of the North Western parts of VAN DIEMENS LAND in the Summer between 1823 and 1824, say the months of November, December and January — A vessel was also to be dispatched to cooperate with the Land expedition on that Part of the Coast —
visible 10 or 12 leagues
41°
42°
1
2
3
4
5
6
7
8
9

We had experienced nothing but bad weather and incessant rain since our departure from Hobart Town and we found it equally impossible to cross the river at Mr. Patterson's. . . . we thought it most advisable to proceed to Patrick's Plains 16 miles farther up where we were told the Shannon is more shallow.

After having procured 2 dogs and filled our knapsacks with provisions we set out on the 11th. The rain continued to pour down in torrents . . . It was late before we arrived at Patrick's Plains and found shelter in a stock keeper's hut . . . the whole country around covered with snow . . . Seeing that for the present every attempt to cross (the Shannon) would be in vain, I despatched Mark Logan and the Stock keeper, Andrew Martin, to Mr. Patterson's for a fresh supply of provisions . . .

On the 20th . . . we proceeded on our journey . . . and succeeded in crossing the Shannon (21st).

We saw numerous Cyder trees which I was told afforded an excellent beverage in summer. The country was well wooded though not super-abundantly.

Towards evening we arrived at the South-West extremity of the Great Lake.

Swan Bay

Jorgensen camped on the South-West corner of Swan Bay, turning off westward over the low saddle locally known as "Murderers'". He met the Ouse at about the position of the old Stock bridge, his estimate of four or five miles reduced subsequently to two, and was inclined at first to identify it as the Derwent.

REPORT

FRIDAY THE 22ND, in the morning we set out early in the direction pointed out in our instructions; and after having walked over 4 or 5 miles of marshes and seemingly good land, we were suddenly and unexpectedly stayed in our progress by a river, which divides some very extensive plains, stretching in all directions farther than the eye can reach. We learned afterwards that this was the Ouse, or more commonly termed the Big River. The depth, magnitude, and rapidity of the current of this river far exceeds the Shannon in those particulars. We followed its banks downwards for about one mile, and upwards for 3 miles but could find no place where to cross.

SATURDAY THE 23RD . . . after tracing the river upwards for about 7 miles I came towards the bottom of a mountain covered with snow, and I now perceived the river pursued an exact Westerly direction . . .

SUNDAY THE 24TH. We took advantage of a clear morning and proceeded at an early hour towards the mountain mentioned yesterday, but after having traversed the same ground I had done the previous day, and walking about 2 miles farther up, I observed the river to take a direction towards the North. This again disappointed our hopes. I entertained some idea that we had advanced nearly towards its source, for we saw two stupendous rocks, between which the water precipitated itself with amazing impetuosity and great roaring which led me to form that conclusion. I lost no time in examining the country beyond the two high rocks alluded to and now found that the river flows in a direction from the North-North-West as far as the eye can reach from the lofty summit whence I saw it.

SEPTEMBER 25TH . . . set out early in defiance of the wet and stormy weather to cross the river about 4 miles higher up, but found the current so rapid and the water so deep that we were under the necessity of returning to our hut.

FRAGMENT OF JORGENSEN'S JOURNAL, GIVEN BY HIMSELF TO MRS. GEORGE SCOTT OF MT. MORISTON, ROSS, AND AT PRESENT IN THE MITCHELL LIBRARY.

21ST THURSDAY . . . weather fine and South by East. We crossed the Shannon at the place mentioned . . . and the (patience)? and sagacity of George (Andrew Colbert) enabled us to reach the S. West point of the Lake before sunset. On the whole we passed a fine tract of land, well wooded, but not superabundantly

and met with large quantities of (Cyder)? trees but not the oak (wattle)? tree. Caught 3 kangaroo . . . White gums mostly. Marshes not ankle deep. In the beginning of the night cloudy with snow and heavy frost. At mid-night the wind came round to the N. West. On the lake beautiful silver sheen.

FRIDAY 22ND SEPTEMBER. After having walked four or five miles over marshes we came unexpectedly to a river which divides a most extensive plain. Stretching in all directions farther than the eye can see, this vast tract of which neither my companions nor myself nor anyone else as far as I know have given an account to for by far the greater part is fit for cattle and sheep and there is no impediment to a good cart road . . . we were all equally disappointed in finding ourselves opposed in our progress by a river of greater magnitude than the Shannon. My companions and myself used our utmost exertions to cross over. George and Logan are however ready and willing to make a desperate attempt to get over tomorrow and I hope we shall be able to find some convenient places.

This day at 1 p.m. the weather became cloudy with much wind and occasionally snow and rain. I consider the tract of land we have seen of a nature to require a more particular examination by some of the company's servants. Some spots might be selected for cultivation.

Began this day to put ourselves on a strict allowance of biscuit and . . . to save all the kangaroo tails for our future subsistence.

SATURDAY 23RD SEPT. In the night the weather was intensely cold and very cloudy. In the morning wind N. West. Moderate breeze . . . I went about 4 miles down the river to see whether I could discover a place where to cross. It was everywhere deep and rapid . . . These plains, without a shadow of a doubt the most extensive in the country, bounded by hills, a river flowing in the middle of them, and adjacent to the lakes, furnish a fine and, in many parts, a luxuriant prospect, and it is therefore I have taken the liberty to call them Arthur's Plains in honour of our esteemed Governor and Chief Commander, Colonel Arthur. At noon the wind North West, fresh and cloudy. I now set out to trace the windings to the North-East . . . We do not find a single trace that ever a white man was here.

SUNDAY 24TH SEPT. The sun rose in great splendour with a strong breeze from the West. Found the river every way is deep and so rapid that we could not cross. We therefore traced it further up and proceeded in a North to West direction for upward of 6 miles and a half. We then observed Table Mount bearing S.S. West distant 12 or 14 miles, a mountain covered with snow N. 1/2 E. and the high mountain seen a little to the Northward and Eastward of the lake bearing East-North-East. Between these two mountains it may not be improbable but that a passage, or ravine, exists, communicating with the North directly to Port Sorell . . . The river now took a westerly direction for two or three miles when again it ran North by West to South by East. We now observed it pouring down with a tremendous roaring, precipitating itself between two stupendous rocks. We ascended a high hill and took shelter for the night. We had traversed fine portions of fine land and had we not been so near Mt. Hellyers track should certainly have returned

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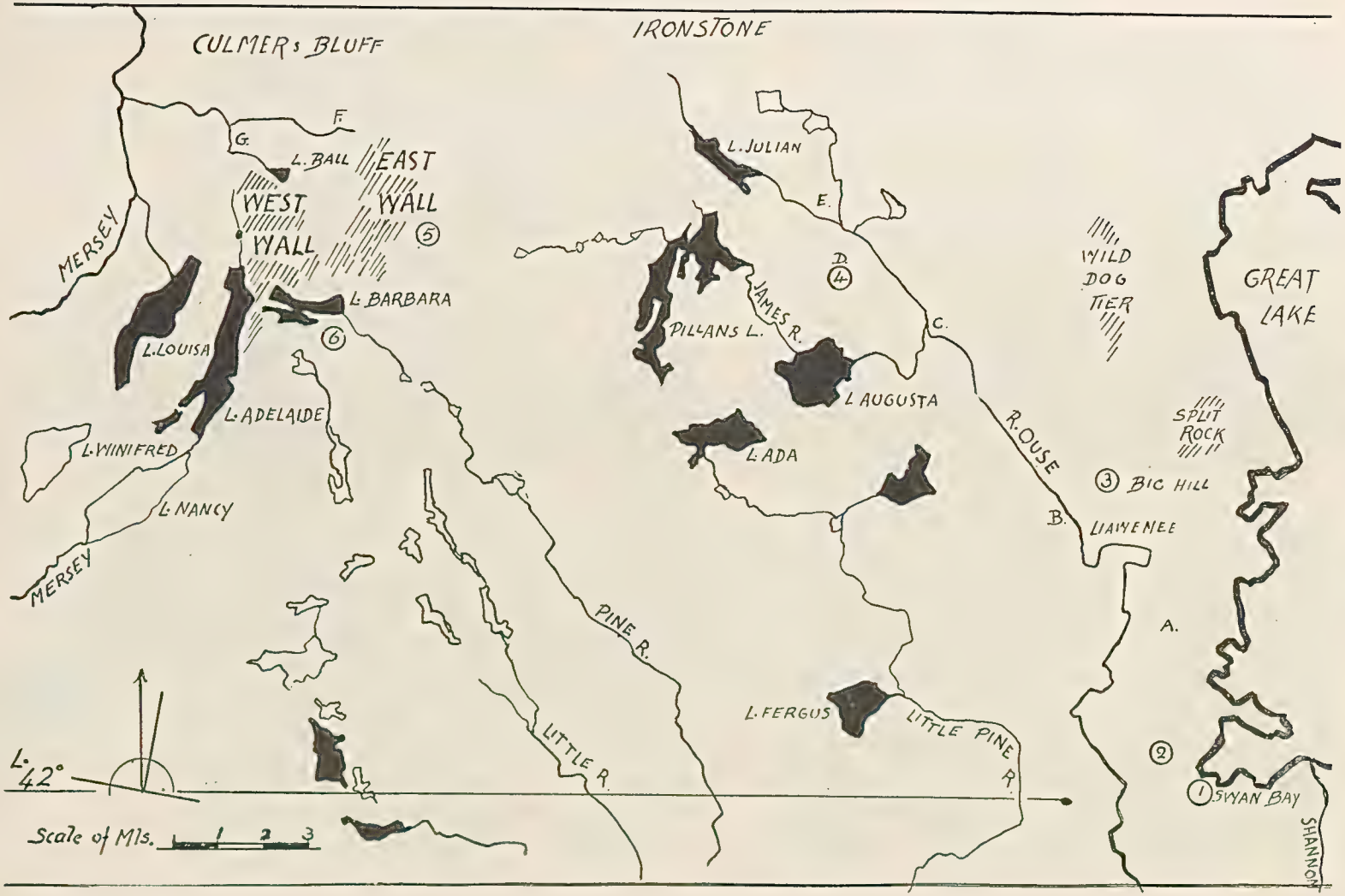
MAP OF THE CENTRAL PLATEAU

With acknowledgments of assistance from the surveys of the Hydro-Electric Commission and from the photographs of the Aerial Survey.

(1) Sept. 21st 1826; Jorgensen camped on the S.W. corner of the Great Lake.
(2) Sept. 22nd.
(3) Sept. 23rd; Hut built on Big Hill near Liawenee.
Oct. 18th and 19th: Jorgensen camped again in this hut.
(4) Oct. 20th. Camped under Little Split Rock.
(5) Oct. 21st. Camp on the spurs of the East Wall.
(6) Oct. 22nd. Hut built after crossing river, S. of the Peak. Farthest point reached.

A. Basalt Plains.
B. Gorge of the Ouse.
C. Crossing-place; junction of James and Ouse rivers.
D. Little Split Rock.
E. The Throne.
F. Officers Marsh.
G. Wild Dog Creek.


CULMER's BLUFF
IRONSTONE
F.
G.
L. BALL
EAST WALL
WEST WALL
5
MERSEY
L. BARBARA
6
L. LOUISA
L. ADELAIDE
L. WINIFRED
L. NANCY
MERSEY
L. JULIAN
E.
D.
4
JAMES R.
PILLANS L.
C.
L. AUGUSTA
L. ADA
WILD DOG TIER
GREAT LAKE
SPLIT ROCK
3 BIG HILL
R. OUSE
B.
LIAWENEE
A.
PINE R.
L. FERGUS
LITTLE PINE R.
LITTLE R.
2
1 SWAN BAY
SHANNON
L. 42°
Scale of Mls. 1 2 3

with the information already acquired. I lost no time in tracing the river farther up above the rocks and could trace it in a N.N. West direction till we lost sight of it in the mountains . . . From our heights we could see the main body of the large Lake bearing direct East distant 12 miles. Consequently the plain on this side runs upwards of 12 miles in width and from 12 to 6 in depth being bounded in the East by the large lake on the West by the river and the North by mountains over which no passage can be found. The land on the opposite side seems to be of the same description as on the river. Abundant feed for sheep and cattle and a considerable portion adapted for cultivation. Even on the top of the heights good feed is found and everywhere the kangaroos are swarming in flocks and are large and excellent eating.

TUESDAY 26TH. The night was stormy beyond conception . . . we proceeded 4 miles up the river . . . where the falls pour over the rocks. We plunged into the water middle deep when we succeeded with much struggling to reach a rock, but we then found the water so deep and the current so rapid that we could venture no further . . . I now endeavoured to follow the fall upwards (that is up the river bed through the gorge.—Ed.). I had to ascend perpendicular rocks and one which I held by gave way and precipitated me several fathoms down . . . The weather cleared and we could observe the Frenchman's Cap bearing W.S. West distant 35 miles, which corresponds to a nicety with our reckoning. We can see about 20 miles forward over the river . . . the river certainly runs more to the southward and northward than I have marked on the chart.

MONDAY 25TH SEPT. We had spent a very uncomfortable night; at early daybreak . . . went to examine the river . . . but found every place unfit. The chart can no longer be depended on as the position of the mountains not as marked on the chart. We have not seen a single kangaroo this day. I now write my letter to Mr. Hellyer which we shall fix tomorrow on a pole on the large plain on the opposite side with a white flag. We shall cross his track tomorrow within a few miles of this place.

The Lofty Eminence Whence Jorgensen took his Observations.

Jorgensen had walked approximately seven miles up the Ouse parallel to the Great Lake, passed a right-angled bend in the river to the bottom of a high mountain covered with snow, to a place where the river pouring between two stupendous rocks which later cost him days to negotiate. This leads him plainly and unmistakably to the Gorge of the Ouse at Liawenee.

His estimated seven miles tracing of the river, his "stupendous rocks" and his latitude all agree to place him on the high broken ground a little above the old bridge leading to the Banks homestead, on the right hand side of the H.E.C.'s present road. This indeed would be the first sheltered camping ground after leaving the Swan-bay corner. The broken ground piles up in successive steps to the summit of Split Rock some three or four miles back from the river. One of the first of these steps is known as Big Hill. From this summit Jorgensen took his bearings. From this summit only does the sky-line coincide with his description (see Skyline No. 1). From the lower hills, the lakes and river-bed are not yet discernable. The possibility of Split Rock itself being his look-out-post was considered for some time, but Jorgensen says nothing about *CLIMBING* his snow-covered mountain and indeed, in weather such as he describes the proposition would be uninviting. An

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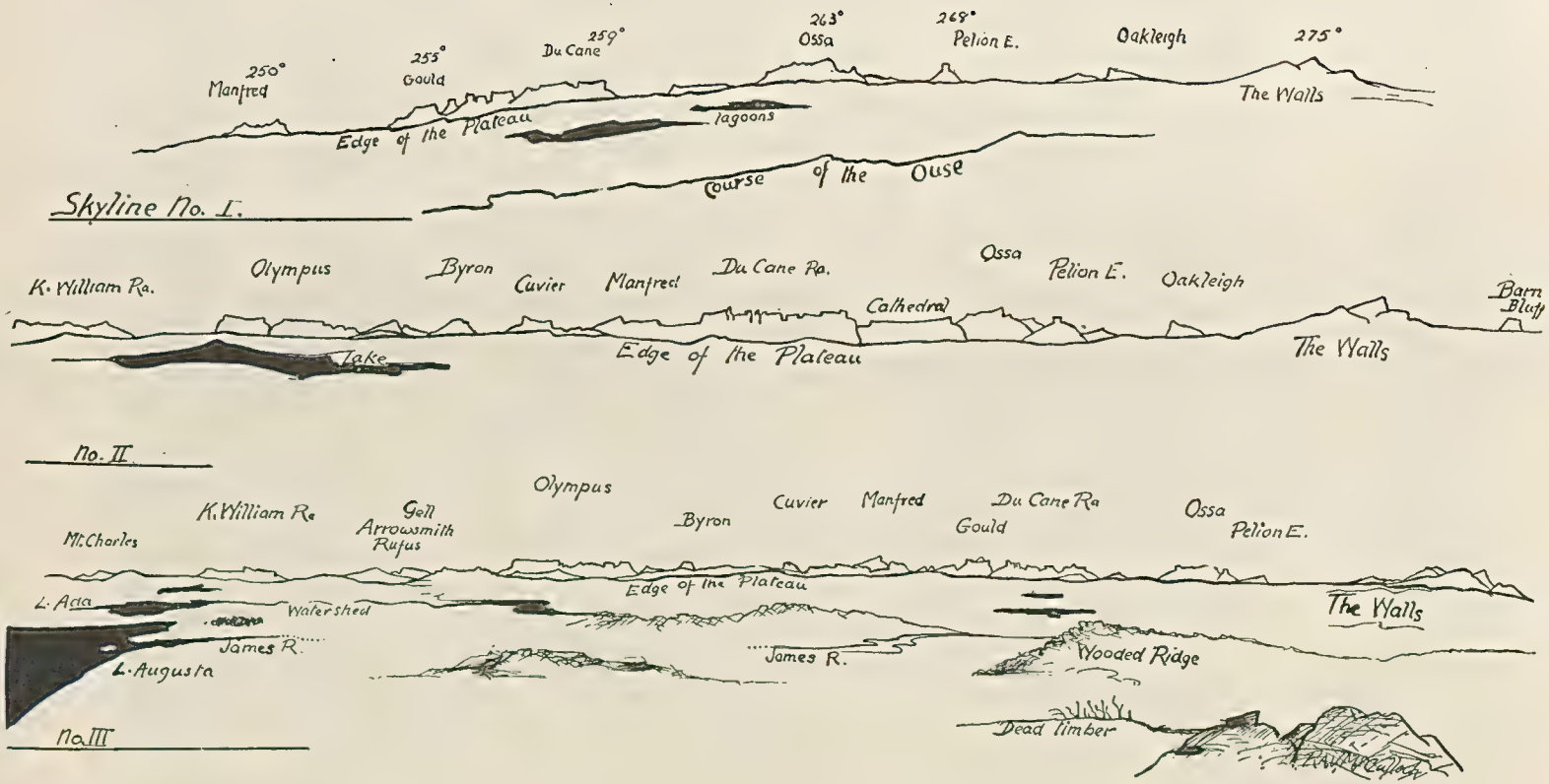
SKYLINE

(1) Western horizon from Big Hill near Liawenee.
(2) Western horizon from Split Rock.
(3) Western horizon from Little Split Rock.


250°
Manfred
255°
Gould
Du Cane
259°
263°
Ossa
268°
Pelion E.
Oakleigh
275°
The Walls
Lagoons
Edge of the Plateau
Course of the Ouse
Skyline No. I.
K. William Ra.
Olympus
Byron
Cuvier
Manfred
Du Cane Ra.
Ossa
Pelion E.
Oakleigh
Barn Bluff
Cathedral
Lake
Edge of the Plateau
The Walls
No. II
Olympus
K. William Ra
Gell
Arrowsmith
Rufus
Byron
Cuvier
Manfred
Du Cane Ra
Gould
Ossa
Pelion E.
Mt. Charles
Edge of the Plateau
L. Ada
Watershed
The Walls
James R.
L. Augusta
James R.
Wooded Ridge
No. III
Dead Timber

actual reconnoitre from the top of Split Rock makes it plain that Jorgensen never saw the mountains from that point. Cradle Mtn. and Barn Bluff become dominant in the N. West; the gaps close as further peaks are raised to view, and the whole western sky-line alters out of any similarity to that described in the journal, forming a continuous wall boundary which encircles the plain without gap or break. (See fig. (Skyline) No. 2.)

Big Hill

There is a certain method apparent in Jorgensen's classification of mountains, lofty eminences, &c. His "mount" is snow-covered, as were the tops of Wild Dog Tier to the north, similar in height. His Table Mt., clear of snow, obviously must be considered a lesser eminence. This is the one place and the sole occasion on which he records a clear view and fixes his latitudes and on the strength of this he laid out his course and orientated himself in the country. Here in the N. West quarter rises the higher and nearer mass of the Walls approximating reasonably enough to the bearing on which he expected the appearance of his "Peak". This group of mountains converges in a crag-and-tail formation which could tolerably well accommodate itself to the anticipated reverse of the "remarkable flat-topped peak" which Flinders described as having "the appearance of an extinct volcano".

Once this is accepted the rest of the deductions become inevitable. Jorgensen, faced with an enormous circular sweep of open moor, identified it with the blank amphitheatre on Scott's map, and fitted Scott's arbitrary mountain ranges to the circumscribing horizon of peaks visible to him.

The course of the Ouse can be traced north-westward as far as little Split Rock which forms the next landmark in the vast expanse of moor. The numerous lakes are identifiable as Lakes Ada and Augusta, the Bar, Double, and Little Split Rock Lagoons. On the S. western horizon Jorgensen saw, as one may see to-day, first the summit of Mt. Cuvier, then Manfred—a gap—Mt. Gould and the Ducane range—a gap—then Ossa, probably snow-capped, and finally the tips of Pelion East and Oakleigh. The apparent gaps provide his promised road to the West Coast. The Ducane mass, "*higher than anything he had seen in this country*" received the name of his patron Dundas, and Ossa he named the Parson's Hood.

The summit of Cuvier is Jorgensen's most probable identification of the Frenchman's Cap. The real Frenchman's is not visible at any of those points of Jorgensen's Route from which he describes it. It is of course obvious that the mountains we know to-day as Dundas (3920) and Parson's Hood (2850) can by no possibility be seen from the Central Plateau, because of the greater height of the intervening ranges. This applies also to St. Valentine's Peak (3637).

Note, however, that in Scott's map the "*Peak*" is placed considerably to the south of its actual position. A line drawn from the Big Hill to Scott's location of the *Peak* will fall within a few degrees of the skyline position of the West Wall.

JOURNAL—*Continued.*

WEDNESDAY 27TH I now shall set down the bearing which I took on a hill exactly due West and 12 miles distant from the Great Lake in latitude 41°–42°. From the summit of a lofty eminence I had found an opportunity, in very clear weather, to observe the whole of the surrounding country; I mean very near the two rocks mentioned under the 24th of Septtember. The country appeared to be vast plains (certainly the most extensive in Van Diemen's Land) encompassed by ranges of mountains, divided by numerous rivers, those to the Westward of the Ouse abounding with lakes and lagoons. The extent of the plains may be more easily estimed when I mention the bearings and distances of all places I marked down at the time. The Frenchman's Cap bore S.W. by W. 35 miles; Mt. Dundas, W. 36 miles; the Parson's Hood, W 1/2 N. 34 miles; other mountains apparently of the same range, from W. by N. to N.W. and so on without interruption, till they join one, the bearing of which was, where we stood, exactly N. about 7 miles distant. In Scott's map no notice is taken of the mountains which form a junction between the range in the N. West and the Frenchman's Cap; the most conspicuous of these is, one of great height far loftier than any I have yet seen in this country, which we named Mt. Dundas; and another we marked Parson's Hood. From the same eminence whence I took my observations, I found the bearing and distance of Table Mt. to be S.S. West 12 miles. This mountain which is situated not far distant from Lake Fergus must ever afford an excellent guide to travellers coming from the North-West parts of the Island. Our greatest distance from Hobart Town was at this time about 100 miles. The country we had traversed exhibited a variety of soils; on the high plains we found rich red clay, partly overspread with small stones and producing feed for sheep. These were dry in all sorts of weather. But all these cannot be seen from the high plains or any other part of the Great Lake . . . Anyone travelling some small distance to the Southward . . . will completely miss sight of them. From the heights it very clearly appeared to us that there existed a practical opening into the extreme West country immediately to the Southward of Lake Dundas and we intended . . . to shape our course directly for that place.

Retreat

For three days snow and rain continued and the river remained unfordable as it was likely to be in such weather and time of year. Logan attempted to swim it with a rope; Jorgensen to climb through the gorge; their hut afforded, he says, little protection from the weather; in spite of an accumulated store of kangaroo tails, provisions needed replenishing. Jorgensen composed a stately letter to Hellyer in case his colleague should come this way, which was to be left on a post set up by the sanguine adventurers in the midst of their expanse of plain, to guide Hellyer towards Hobart. They retraced their steps, reaching the hut at Patrick's Plains on the 27th September and Ross's farm at the Hermitage the next day. At this stage the fragment of Journal ends.

They found the country disrupted by a raid of Dunn's bushrangers, and rivers still in flood; nevertheless, Logan carried Jorgensen's report of progress, up to date, back to Hobart, crossing the flooded Shannon on a fallen tree.

On October 11th they started again with knapsacks refilled, taking time to examine the country between the courses of the Ouse and the Shannon, which Jorgensen describes with considerable accuracy as to timber and soil.

The Crossing

From their previous camp at Liawenee, they pushed up the east bank apparently as far as Thompson's Rivulet. The James River, almost base-level, drains through Lake Augusta and the moors on the western side. Above the junction, the current slackens, shallows, and the stream widens

out. The Ouse diminishes in volume and its course slants N.N. West toward its source in Lake Julian and the Ironstone. Here the crossing was comparatively easy.

REPORT—*Continued.*

OCT. 18. On the morning of the 18th we arrived at that part of the Ouse which we had first seen after leaving the Great Lake on our former journey. We deposited our knapsacks in a safe place amongst some rocks, and immediately set about measuring the depth of the river . . . but to no purpose; we again resumed our knapsacks and set out for the hut we had constructed on the 24th September last, and where our former career had terminated. [That is The Big Hill, Liawenee.—Ed.] After several fruitless attempts to cross the river, we departed on October 20th and with an intention of tracing it along its banks to its source. The weather was stormy, cloudy, and hazy, so that we could see but a little distance before us. I was now interrupted by a river, also falling into the Ouse and running in a N. by E. and S. by W. direction, and apparently taking its source in that ridge of mountains which is marked "supposed ridge" on the map you furnished me with. A little farther up on the opposite side, a river also empties itself into the Ouse, deriving its waters from a Lake in the western plains. We crossed the Little River (7 miles from our last night's station) which was sufficiently deep and rapid; and then proceeded 4 miles higher up in a N.W. direction. . . . and here we observed a place that might be forded. We now proceeded in a direct Western course, ascended stony hills of great height and fixed our abode for the night among some rocks. From hence we perceived the river to run in a N.N.W. direction till we lost sight of it in the mountains.

Little Split Rock

Here the country rises in one of its successive steps to the high rocky lightly-wooded mass topped by Little Split Rock, a very definite landmark on the west bank of the Ouse, visible for miles in any direction across the surrounding moors.

On the east bank, two or three miles farther upstream, rises a smaller peak called locally "the Throne" by shepherds and hunters, or "the Devil's Den", by H.E.C. surveyors. Both these rocks resemble nunataks, standing clear above the glacier-levelled moor. The course of the Ouse bends westerly toward its source in Lake Julian. The sheer walls of Little Split Rock face eastward toward the Ouse, and make a dry, sheltered, and obvious camping-place a little above the altitude of Mt. Wellington. Here, as in Jorgensen's experience the compass becomes unserviceable, and in 1940-45-46 all bearings were taken by the sun at midday. Jorgensen took his, apparently, from the level of the moor. This is the first occasion on which he records a bearing for his "Peak like a Volcano" and plots his general course toward it West by North. [Note: Normal compass deviation in this area is 10° East.]

REPORT—*Continued.*

OCT. 20TH. I stood on a lofty and rocky eminence and, to my surprise, perceived, when placing the compass on a rock that its vibration was so quick that I could make no observation by it. I had to descend to lower ground.

I observed Mt. Dundas bearing S.W., the Parson's Hood S.W. by W., the Peak like a Volcano N.W. 1/2 W., Table Mt. S. by E., the Great Lake about S.E. We had been forced a great way farther to the Northward than was consistent with our views. The country presented nothing of service to man; it was rocky and thinly wooded.

SUNDAY, THE 21ST OCTOBER. The weather was gloomy and hazy, but as I had yesterday afternoon taken a view of the country, I found no difficulty in shaping our route West by North. A river about 4 miles from our last sleeping place

presently interrupted our progress. It empties itself into one of the lakes in the plains, and we were again forced into a Northern course along its banks. We were impeded by lagoons and large basins of water. After proceeding 7 miles upwards, we at length observed a place where to cross with the aid of a stout line. Our route now lay thro' thick scrub and over high rocks and stony valleys. The country assumed a sterile and desolate appearance and kangaroos not to be obtained. We were all this time steering for the mountain marked Peak Like a Volcano. We found it difficult to fix on some place among the rocks for shelter during the night. We saw few trees hereabouts; chiefly red and white gum of diminutive sizes.

SUNDAY THE 22ND. After a dark and rainy night the sun came out clear in the morning. We proceeded to the Peak but keeping in a course a little to the southward of its summit. It was so deeply covered with snow that it would have been imprudent to have attempted to ascend the top of it. Difficulties of no ordinary description now began to thicken fast upon us. The snow in some places lay 5 feet deep, and we had to step from rock to rock where the least false step would have proved fatal to us. We made little progress tho' we walked quickly having so many winding courses to take to avoid the higher cliffs, rocky summits and deep gullies. We observed from a lofty eminence that the Peak only communicated with the range of mountains before us by means of uneven ridges of rocks, and we beheld a frightful chasm many miles in width, to the view of bottomless gulph. To avoid these we proceeded a little more to the westward, but were again obstructed by a river. This river runs in a North and South direction and issues from a large and magnificent sheet of water, which is formed between the Peak and the large range of mountains already described. The dreary and barren country around us supplies nothing for food; even the crows had deserted this inhospitable region; our dogs were in danger of starving, but we spared them what little we could out of our stock. During the night our hut afforded but a slight defence against the inclemency of the weather, and we were distressed for fuel.

MONDAY, THE 23RD OCTOBER. The weather continued stormy, wet and cold. We pursued our route in the morning round the South part of the large basin, but, after some painful walking we observed that the lake is the source of at least two rivers; the one is that I have just noticed, the other is broad and rapid flowing towards the S.S. West along the range of mountains and afterwards pursues a S.S. East course. No carts can ever cross in this direction, neither can sheep or cattle be driven across even in the summer season. The snow was falling in a dense shower, our clothes torn to tatters, and we therefore returned over the river. We were about 28 miles distant from the mouth of Pieman's River and 46 from Circular Head. During the night a gale blew hard from the Westward, the snow fell without intermission, and the frost was so severe that the snow on the two ends of the log of wood which was burning in the middle would not melt.

TUESDAY, THE 24TH. The dawning of the morning presented a scene of desolation and terror. The snow had fallen 2 feet during the night. It now become a matter of prudence and of absolute necessity to descend into the lower country without delay. But Andrew Colbert (the black man) seemed to be seized with a species of lethargy and would willingly have remained in the mountain. I was obliged to cut up what flannel I had with me to provide my companions with pieces to cover their feet which were benumbed with cold.

Little Split Rock to the Walls.

The route from Little Split Rock to the "Peak" is not so exactly landmarked but can be placed by elimination. Jorgensen wished to go Westward but was forced North by the lie of the country. This is so to-day. He did not, however, come upon Lake Pillan, whose seven odd miles length seem to lie across any path plotted in that direction, and would have made, with its picturesque chains of inlets and island clumps of pines, almost as imposing a subject for Jorgensen's pen as the Great Lake itself. He crossed a river, the James River, evidently a little below its source, and consequently South of Ginger's Hill. His route, as he says, was a continuous ascent. This is supported by his decription of

the country. It places him finally on the highest and most inhospitable area of the Plateau somewhere on the divide between the Pillan and Pine River watersheds, at the foot of the East Wall with the snow-covered "Peak" of the West Wall looking threateningly out of its habitual screen of bad weather ahead. He did not attempt to climb it. He is not to be blamed if it held no attraction for him. He did not penetrate the inner valley containing Lake Ball which lies within the walls, or the outer valley of the Officer's Marsh. He would not have passed without describing the descent of defiles and enclosing saddles or the changed watershed on the Mersey side. He kept to the high and open Southern shoulders of the East Wall or Bluff Point.

The Walls are a nexus of three mountain masses roughly enclosing a triangle with exit or "gates" at the intersections.

The system is placed fortress-like on the tilted northern edge of the Central Plateau with its greatest height facing to the North-West over the Mersey and Forth gorges. From it radiate walls and ridges enclosing several lakes, one of which, Lake Barbara, provides Jorgensen's source of the Derwent and of another unnamed river.

The Lake under the Peak

Lake Barbara lies in an amphitheatre (Jorgensen calls it a basin) between two outlying buttresses to the South-Western side of the converging East and West Walls divided from Lake Adelaide only by a narrow ridge but its outlet falls to the South and its waters eventually join the Derwent drainage system.

This is the lake and it is indeed a considerable sheet of water, which Jorgensen found and believed to be the source of the Derwent. It contains an island and spreads like a star-fish in miniature fiords between the rocks up and down—which under the force of the west wind, the lake water may be seen driven with the appearance of a strongly flowing current.

Here lies the only practicable explanation that has ever presented itself for Jorgensen's description of the lake as the source of at least two rivers. In the scanty shelter of this amphitheatre he made a camp on the night of the 23rd while a gale blew and the snow fell around them and froze on the logs of their fire.

Jorgensen tells a good story. His description of the "bottomless gulph" which barred his way to the Pieman is dramatic enough to justify his turning back.

Actually from the top or shoulder of the East Wall (one more of his "considerable eminences") he looked at the great gorge of the Mersey "miles in width" past Cathedral Mt. and leading into the tangled mass between the Du Canes, the Guardians and the Pelions.

Looking at it in a murky sunset one acknowledges Jorgensen's purplest patches justified.

Considering the weather and the season of the year, a braver man and one more experienced in the country, could reasonably have turned back earlier.

REPORT—*Continued.*

Unwilling to relinquish the object of our expedition, and being desirous of information, I kept to the Westward in my descent, to take a nearer view of the passage I supposed to exist immediately to the Southward of Mt. Dundas. Altho' the weather continued hazy and the snow fell incessantly, we proceeded onwards with great alacrity. The country from Hobart Town to the Peak is one perpetual ascent, and therefore more difficult to travel than when returning.

WED. THE 25TH. We continued in a Southerly direction inclining by the lay of the country a little to the East, and we hailed with satisfaction the appearance of kangaroos, which relieved us from anxiety on the score of wanting provisions. The land now began to assume a more favourable aspect, well adapted for grazing and cultivation. Abounding in wood, such as Stringy Bark and Gum both for building and fuel and affording shelter for sheep and cattle.

After having passed a river we encamped on its banks for the night.

THURSDAY, THE 26TH OCT. The wind was high and the rain poured down in torrents. Since leaving the Peak the weather had been so hazy we could not discern any object we were acquainted with, we therefore travelled solely by the compass . . . The luxuriance of the vegetation, the size and strength of the trees (stringy bark and gum), innumerable tracks of wild cattle; swamps of brush and forest kangaroos all supplied indications of good country and milder climate than we had lately visited. We made several attempts to veer more towards the W. but the nature of the country impelled us towards the S. After passing a river or two we arrived on the borders of a capacious lake which according to our computations ought to be Lake Fergus, but I could scarcely flatter myself that after having observed no marks to steer by for four days past my reckoning should be so correct. What rendered me more dubious, the sheet of water I saw was scarcely inferior in dimensions to the Great Lake, whereas Lake Fergus is marked on the chart as of very minor extent.

FRIDAY 27TH. Everywhere about the lake we observed land which elevated itself in a species of amphitheatre. After walking for several miles over a fine tract of land, we espied the tableland near the Clyde and the two sugar-loaves not far distant from the Shannon point . . . .

On our return (to Hobart Town), we avoided the Shannon and proceeded by way of New Norfolk.

We arrived in Hobart Town on the 1st of November.

(Signed) JORGEN JORGENSEN.

Return

After the retreat from the *Peak,* Jorgensen's narrative becomes much less particular. The river he described on the 23rd, rising from the Lake under the *Peak,* he concludes to be the Derwent and accepts as impassable. He notes a rapid descent in his two days' walking and is justifiably doubtful of his identification of Lake Fergus.

To Lake Fergus, bleak and exposed on the high moor within ten miles of the Great Lake, Jorgensen's description will not apply. He has passed a river or two, but gives us nothing by which to distinguish Pine, Little Pine, or Little Rivers.

From his description of country and estimate of distance, it was almost certainly Lake Echo on which he camped on the night of the 26th and the known landmarks of the Clyde and the Shannon settlements could easily be picked up in the next day's journey.

It was Jorgensen's ill-luck that where he had a fixed point to aim at (as in Flinders' Peak and the Frenchman's Cap) he lacked the means to identify it correctly and consequently mis-orientated his calculations—that where he discovered and named a landmark (as in Mt. Dundas) later generations have shifted his names to features which make nonsense

of his description of them—that his references are often related to data, current at the time, which since have lapsed into obscurity—and that his reports of his findings are so concerned in presenting a picturesque case to his employers that they have discredited the bulk of remarkably accurate observation submerged in their turgid rhetoric.

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NOTES

(1) *Cyder Trees* are mentioned by several early writers but when searched for are so elusive as to appear mythical. It took several years and a number of visits to locate individual trees which could be attested by creditable witnesses to produce or to have at some time produced a flow of sap. Examples were recorded by Mr. Allison and his shepherd, and by Mr. Archibald Wilson of the Steppes. The particular trees are still growing on ridges between the Steppes and Miena and near the Lagoon of Islands. All are in the area where Jorgensen describes them.

(2) *Frenchman's Cap,* though one of the fixed points on which all Jorgensen's reckoning depended, is actually not visible from any part of his route. After a process of exhaustive elimination during 1946-7- and 8, there appears one point (limited to a few yards in each direction) near the Skittleballs Plains, where, in clear weather, the very-distant Frenchman's can be described, aligned in the gap of the Little Pine River. There is no evidence that Jorgensen touched this spot.

The Cap is visible again, in clear weather, from the top of the West Wall, but Jorgensen made no attempt to climb his *Peak,* and recorded only the poorest of visibility while there.

From any other part of the Plateau, the intervening masses of Hugel, Rufus, Arrowsmith, Gell and the King William Ranges block any possible view. Even if the altitude were sufficient, the bearing given is an impossible one and the estimate of distance (usually surprisingly accurate) shows that he was looking at a much nearer landmark, one, in short, on or close to the edge of the Plateau and not far removed from the two new mountains which he named Dundas and Parson's Hood.

(3) *Table Mountain.* Table Mt. (3598) lies in a south-eastward direction across the Great Lake from Jorgensen's given view-point. The bearing he records makes it necessary to find another landmark to fit the description, one within the bounds of the Plateau, and, since it is recorded as free of snow, it must be a lower and smaller feature than Split Rock and Wild Dog Tier which are both described as snow covered.

The clue lies in the words "to the traveller from the north-west, must ever afford an excellent guide . . ." towards Hobart.

It was from the north, from the height above Pillans' Lake, in January 1947, that a table-topped ridge near Skittleballs Plains took shape in the required position, south of Lake Fergus. A corrupted variant of the name is still in local use.

Reference to "Eastern Table Mt." and "Western Table Mt." as landmarks in Macquarie's itinerary of 1811 give evidence of established familiarity with more than one landmark of that description.

(4) *James Scott's Chart of the Jerusalem Walls Area,* 1846. Even at this early date the names of Lake Adelaide, Lake Ball, Wild Dog Creek, Bluff Point, and Officer's Marsh, were evidently well-established in current use and something over a century's tenure should protect them from displacement.

Lake Louisa is marked " un-named " in the 1846 survey and the names of " Lake Barbara ", " Lake Winifred ", and " Lake Nancy ", were given by A. L. Meston and C. S. King when they first recorded these lakes in 1927.

In some recently published maps, confusion has arisen between Lake Ball within the Walls, source of Wild Dog Creek and draining to the Mersey, and " Lake Barbara " which lies to the south of the Walls and drains toward the Derwent system.

(Editors' Note.)

(5) *References.* In the Clyde Company Papers and in E. T. Emmett's Short History of Tasmania the Jorgensen legend is treated with some reserve.

S. H. Roberts' History of Australian Land Settlement, however (chapt. VI) has provided the source of many subsequent quotations.

Roberts claims that Jorgensen crossed " the very roof of the island ", forestalled Hellyer by five months in the discovery of the Surrey Hills, and consequently reached St. Valentine's Peak five months before Hellyer named it.

Jorgensen's route, as shown on Roberts' map, is totally impossible. He is represented as having left the Central Plateau near the Fish River, passing to the north of Cradle Mt., yet in travelling from the source of the Ouse he did not cross the Mersey. Had he made such a journey, he must have crossed the river where it is of considerable size and runs through a mighty gorge and heavy timber. Jorgensen never failed to give a highly-coloured picture of his adventures, and had he met with this or with the mighty Forth Gorge we should undoubtedly have heard of it. And if the Ouse was impassable after a September's rains on the Central Plateau, what must have been the condition of these two rivers?

When Jorgensen reached his " Peak like a Volcano ", he was impeded on one side by the mountains and on the other by the large river he supposed to be the head of the Derwent; that is, the river ran south. To anyone who knows the country (surrounding St. Valentine's Peak) this statement makes the claim ridiculous.

On the return journey Jorgensen must needs have crossed the Fury Gorge—an impossible feat—and travelled far enough south by way of the mountains we know today as Parson's Hood and Mt. Dundas to make the necessary approach to the Frenchman's Cap, returning by Lake St. Clair. Lake St. Clair fits none of Jorgensen's descriptions. It has no mountain-mass resembling the known Peak like a Volcano, and lies far south of the latitude and bearings on which Jorgensen plotted his course. The surrounding country is forested, and a thousand feet lower than the Ouse plateau, whereas Jorgensen tells us that he climbed steadily toward a climax of peak, lake, and bad weather, and that he was distressed for fuel. Finally, the route shown would bring Jorgensen to Lake St. Clair from the west instead of from the east, while the country between it and the settled areas shows none of the abrupt descent and changing character described by Jorgensen on his return journey.

Roberts himself admitted—" If the critic . . . can prove that it was a matter of physical impossibility for Jorgensen to have made the journey in the time, then he has me ". The country proves this; and Curr in a letter to the Court of Directors clearly states that the map sent by Jorgensen to the V.D.L. Co. (on which Roberts' argument was based) was a fabrication.

(In Chapter 18, p. 263, of " Governor George Arthur ", M. C. I. Levy states that Jorgensen " pushed his way in 1826 from the Shannon to Circular Head ", a generosity of estimate which out-rivals Jorgensen's own.)

Editors' Note.—Since the preparation of this paper, a popular life of Jorgensen, " The Viking of Van Diemen's Land ", has been published by Frank Clune and P. R. Stephenson, and has added considerably to the existing apocrypha. The chapter on Tasmanian exploration is based largely on Roberts' interpretation, but if earlier claims were made without knowledge of the country, this chapter appears to have been written without benefit of a map. In addition to the earlier claims, these writers credit Jorgensen with the discovery of Mt. Bischoff, identifying the rock which deflected his compass as Mt. Magnet. As Jorgensen describes the camp made among the rocks on the night of the 18th directly after the crossing of the Ouse, it is evident that they did not have access to Jorgenson's own record.

Size Variations in Tasmanian Rabbits

By

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(with 2 text figures)

Abstract

In Tasmania, the great differences in relief and climate within comparatively small tracts of country, gave rise to considerable size variation in the rabbits, *Oryctolagus cuniculus* (L.). According to extensive counts, four main types of size could be found. Males show considerably greater variation in size than females, their final development depending mainly on the availability of herbage and the absence of frosts in the earliest stages of their development.

(*a*) Introduction

The number of rabbits, *Oryctolagus cuniculus* (L.), in Tasmania, was estimated at 40 million in 1953 (Hughes, 1953). Of these, over one-third lived on the plains between Hobart and Launceston, comprising the Midland area, where rabbits first became established over a hundred years ago. They built up their greatest numbers on and around the levees bordering the rivers and water-runs and in marginal agricultural country, where cultivated land gives way to bush.

Next to the Midlands, the rich Tertiary basaltic soils on the north coast of Tasmania, supported the most important concentrations of rabbits. However, these basaltic flows cover climatically and in relief vastly different areas, varying from the rich and almost frostfree farming country at Forth and Wynyard, to the most rugged and dense rain forest regions, with over 80 inches annual precipitation and frequent frosts for eight months of the year, e.g., at Waratah.

Rabbits, with their great capacity to adapt themselves to totally different environments, seemed to follow the well-drained, thick basaltic soils, as next to the availability of herbage, the choice of warrens and hideouts seem to be the main factor in determining the lines of migration.

It is only natural that there is considerable diversity in size and colour in different geographical regions, as this prolific and quickly maturing animal adapted itself within a short period to various environmental conditions.

Some of these local variations were long known to be in existence, but it was only recently that H. N. Barber and his party started to examine critically the colour mutations (Barber, 1954).

(*b*) Results

Here I endeavour to give a record of the diversity in size, of which there are four main types in the State:

A. *Midland Rabbits.* Characteristics: early breeding, late development and sexes being scarcely distinguishable by size.

B. *North Coast Rabbits.* Characteristics: early breeding, early maturing and distinctive difference between the size of sexes.

C. *Scrub Rabbits.* Characteristics: late, but prolific breeders, late maturing, no marked difference between the size of sexes, both being relatively small.

D. *Highland Rabbits.* Characteristics: late, but prolific breeders, quick maturing, average sized males, but relatively small females.

A. *Midland Rabbits.*

The largest concentration of Midland Rabbits are found around Ouse, Hamilton, Jericho, Oatlands and Nile, all in typical pastoral country with 18-25 inches annual precipitation. Spring frosts are frequent and the average minimum temperature is close to 35° F. in July, August and September, i.e., at the beginning of the breeding season. During these three months night frosts followed by sunny days are the rule, the latter being inducive for early breeding. Having a new litter of 4-5 kittens in each forty days cycle, from July onward, the number of rabbits builds up rapidly during the spring, competing with the sheep for the normally not too dense pastures. It must be the combined effect of frosty spring nights and the nature of pasture that produced in the Midlands the finest wool and the most highly priced rabbit fur in Australia, off a sheep and rabbit which are relatively small in size.

Observations carried out at the export works of Brooks & Co. Pty. Ltd. at St. Leonards, show that 2400 rabbits from this area, cleaned and packed in fur between February and April, 1954, averaged 2·3 lbs. each, the males weighing 2·38 lbs. and the females 2·23 lbs. All weights mentioned in this paper refer to cleaned (gutted) rabbits in fur.

As these figures indicate, there is rather small difference in size between males and females. Compared with other varieties, the smallness of the males becomes evident. This is brought about, presumably, by the cold weather and sparseness of food during the gestation, suckling and early growing periods.

B. *North Coast Rabbits.*

The North Coast of Tasmania, Scottsdale, Forth, Ulverstone, Burnie, Myalla and their inland districts used to support the largest rabbit populations before the advent of myxomatosis and large scale poisoning with sodium fluoracetate ("1080"), the latter starting in April, 1954. The rabbits around Myalla had the fame of being the second largest rabbits in Australia, next only to those of the Mildura district in the Murray Valley.

Myalla's and Burnie's average minimum temperature in July, August and September is almost 10° F. higher at 44·5° F. than that of Oatlands. The coastal strip is almost frost free. The young rabbits are well-protected by deep burrows in the ideally drained loamy soil and there is no shortage of early herbage. Rabbits in this region have every chance to reach the maximum of their innate potential for growth. In February, March and April, 1954, 2400 rabbits from the Myalla district were weighed. They averaged 2·80 lbs., the females being 2·56 lbs. and the males 2·98. However, to get a clear picture, we must take it into account that some old males frequently weighed up to 4 lbs. Among young rabbits, weighing less than 2¼ lbs. cleaned, there were 53 per cent females and 47 per cent males, indicating that at this stage of their development, there was yet no marked difference between the size of sexes.

A separate observation has been designed to obtain data on the rate of growth of the young rabbits. On three different properties, burrows were ripped up and the young rabbits marked by clipping the ears. Trapping followed at monthly intervals, when the marked rabbits caught were separately measured and weighed. The results always confirmed that there is no decisive difference in the size and weight between sexes, before reaching maturity at 5-6 months of age. From this age onward, the males show a quicker and more prolonged rate of growth than the females (see also fig. 2).

TABLE No. 1.

The growth rate of rabbits as shown by recaptured individuals.

Age of rabbits	Date of Capture	1st plot (181 rabbits)		2nd plot (98 rabbits)		3rd plot (242 rabbits)	
		♂	♀	♂	♀	♂	♀
3 months	Feb. 20-25	1·38	1·36	1·45	1·46	N.a.	N.a.
4 months	March 18-25	1·79	1·78	1·91	1·91	1·65	1·63
5 months	April 20-24	2·15	2·12	2·28	2·26	1·98	1·97
6 months	May 20-25	2·22	2·20	2·48	2·40	2·18	2·15
7 months	June 16-24	2·28	2·21	2·62	2·50	2·23	2·18

c. *Scrub Rabbits.*

The Scrub Rabbits are found mainly around the small clearings carved from the rain forests and bush on the slopes of the foothills bordering the plains and occasionally following the roads and river valleys. Upper Blessington, on the way to Ben Lomond, and Liffey, at the foot of the Western Tiers, the high lying mining towns of Moina and Mathinna in the North, and Bronte in the South, are typical examples.

All these places support large populations of small rabbits in over-grazed, frequently isolated patches. The long winters, with not infrequent snow, as late as November, and the short growing season are inducive neither for early breeding, nor for quick or full development. Rabbits were measured and weighed from Upper Blessington, Liffey and Moina. In each case, the sample taken was 250 rabbits and the average cleaned weight in fur was 2·30 lbs. in April, 1954. Weights of males and females

did not show any marked difference. There is no data available from the spring period, but it appears that during the short summer growing season, the mature females reach a size approaching that of females from the Midlands, while males remain comparatively small, never reaching their full growing potential.

D. *Highland Rabbits.*

Rabbits in Tasmania also successfully colonized parts of the over 2000 feet high North-western and Central Plateaux.

In the North-west they followed the volcanic soil on the sheltered side, where it projects deep in the mountains, as at Wilmot-Nietta or Parrawe-Waratah. In these districts better soil makes for better undergrowth in the rain-forest, which is also intersected by semi-cleared (often burnt) strips of cattle grazing country. The rabbit thrives even in areas of 85 inches annual precipitation, adapting itself quickly to the abundant pasture growth of the short summers. Breeding season at Parrawe lasts from October to February. But while the number of young is averaging 5-6 in the coastal areas, litters of 10-11 seem to be the rule in the Highlands.

It has been suggested that large litters result in smaller rabbits. However, this is contradicted by the fact that Highland Rabbits are somewhat larger than Scrub Rabbits and that adult males among them are usually more heavily built than the females.

Large colonies of rabbits also exist around the Great Lakes on the Central Plateau. While they are just as prolific breeders as those of the North-western Highlands, and their females resemble in size the Scrub Rabbits, males seem to vary in size according to soil and vegetation in different localities.

An important characteristic of Highland Rabbits is the sturdy, thick-set character of the males compared with the Midland counterpart.

There are opinions that Tasmanian rabbits might not all come from the original stock, which was well established around Hobart as early as 1827 (Colonial Times, 1827). However, the most remarkable size variations, namely, those around the North Coast, were the results of comparatively recent migrations. Rabbits spread over the North Coast only during the last 50 years. Seventy years ago they were rare around Deloraine, forty years ago only kept as pets around Burnie, and they appeared in the Circular Head district not more than 15 years ago. In the last half century it has been illegal to introduce them and the control was adhered to strictly. The original stock migrated in waves from place to place, following the lines of settlement and—as in the case of Circular Head—the new railway lines.

The rabbit remains in its area if not disturbed. Floods, droughts and large scale destruction are the usual factors forcing it to migrate. Only this year, the government's poisoning campaign caused them to withdraw from certain districts overnight. After migration, the surviving members of a new generation start to form a new strain, which is better adapted to the new environment.

Studying their variations in size, the most remarkable features are:

(1) The growth of males responds to weather conditions and the quantity of available food during the *early* stages of their development. Where adverse conditions prevail during this period, males do not develop to a large size. (See fig. 1.)

(2) Females are still able to reach approximately 90 per cent of their potential size, if conditions improve at a later stage of their development.

(3) Short growing seasons result in smaller rabbits. (See fig. 2.)

(4) The size of litter does not seem to affect growth.

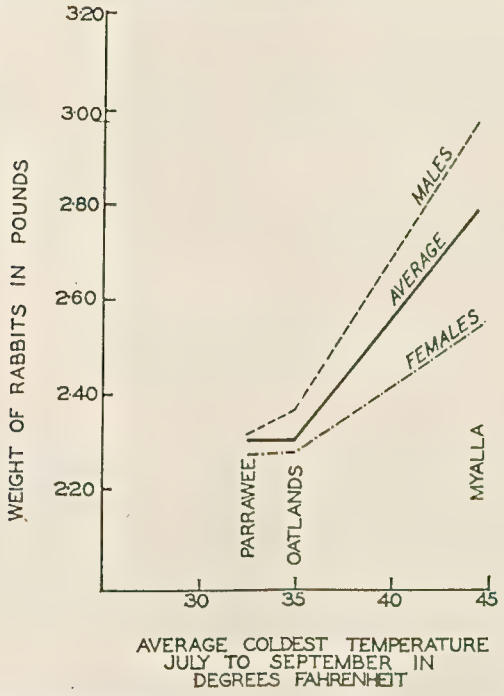

FIG. 1.—With minimum temperatures during the early breeding season, the average size of mature rabbits increases. This increase is more regular in males.

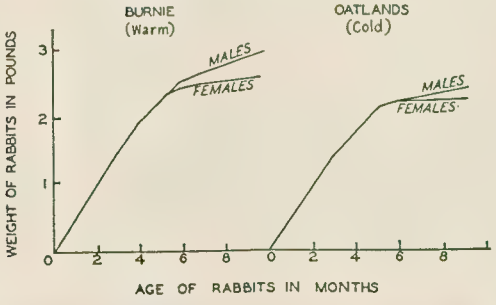

FIG. 2.—The growth of rabbits in warm and cold spring climate.

Acknowledgment

I wish to thank Mr. D. Best and Mr. E. A. Coleman for their assistance during the work in the field: Dr. Guiler and Mr. P. Scott for manuscript advice.

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Observations on some Tasmanian Fishes: Part VII.

By

E. O. G. Scott

WITH 1 PLATE

Abstract

Two Tasmanian records of *Lepidotus squamosus* (Hutton, 1875) (Lepidotidae) are given. *Clinus johnstoni* Saville-Kent, 1866 (Clinidae) is referred to *Petraites* Ogilby, 1885, and a key to the family is provided. *Syngnathus mollisoni sp. nov.* (Syngnathidae) and *Clinus puellarum sp. nov.* are described and figured.

[By an unfortunate mischance, the outcome of a curious train of circumstances the last contribution in this series published in the 1952 number of this Journal (Vol. 87, pp. 141-166), issued August 1953, was misnumbered Part V: it should have been numbered Part VI, Part V having appeared in the volume for 1941 (pp. 45-53), issued June 1942.]

Except where otherwise specified linear dimensions are given throughout in millimetres, the name of the unit normally being omitted.

Family SYNGNATHIDAE

Genus **Syngnathus** Linné, 1758

Syngnathus mollisoni *sp. nov.*

(PLATE I, FIG. 1)

Diagnosis.—Size about average for Australian species of *Syngnathus*, habit slender. Mediolateral trunk ridge not continuous with inferolateral tail ridge. Annuli 20 + 44. Dorsal with 28 rays; base not distinctly elevated, length about half distance from pectoral origin: subdorsal annuli 2·8 + 7·0. Snout about three-fifths head, about one-fourth length to vent; low rostral ridge. No opercular keel. Shields without spines. No filament above eye. Trunk about one and two-thirds, tail with fin about four, times head. Tasmania.

Description of Holotype.—Head 2·5, 2·7, 6·4, 6·6 in length to dorsal origin, vent, caudal base, caudal tip. Eye 5·6 in snout; the latter 1·7 in head. Interorbital 1·5 in eye. Length of pectoral from front of base 4·8, from middle of base 9·6, in snout. Length of a middle dorsal ray 4·8 in base of fin; the latter 3·6 in its distance from tip of snout. Caudal 6·9 in head. Width in depth at levels noted: middle of snout 1·3, front of eye 1·0, opercular margin 1·4, vent 1·3, middle of tail 1·1; maximum width in maximum depth 1·2.

Smooth, without spines. Main longitudinal ridges low, but clearly defined. Head long; in general little compressed, but with distinct lateral constriction at junction with trunk. Snout long, subequal to twice distance from middle of eye to opercular margin, less than dorsal base by about one eye-diameter; slightly compressed; at nostril about half as high again as immediately behind mouth, but no conspicuous

crest formed: in anterior two-thirds dorsal surface narrow, almost flat; thereafter each dorsolateral ridge, diverging from its fellow, swings down below middle of front of orbit, bounding narial basin inferiorly *en route,* the dorsal surface thus coming to be constituted posteriorly of two upwardly and inwardly sloping planes, enclosing an angle of 70-80 degrees: an obscure mesial ridge from tip of snout to level of nostrils, where it appears to subside, being replaced by two still more faintly indicated ridges, which rapidly diverge, and cease near posterosuperior border of orbit. Supraorbital ridge low, but distinct; continued anteriorly to posterosuperior angle of narial concavity, where it joins a very low ridge that constitutes the superior border of the basin and thereafter runs forward to meet the downswinging rostral ridge; continued posteriorly, rather faintly, to near highest point on operculum, its maximum distance from its fellow, occurring here, about half as great again as its minimum separation between midorbits. A short proconvex elevation from near point of concurrence of supraorbital, supranarial, postnarial ridges to junction of median rostral ridge with faint paired interorbital ridges. Eye moderate, diameter about one-third distance from middle of pectoral base; twice as far from ventral as from dorsal profile. Interorbital space very slightly concave: a narrow groove from end of mesial rostral ridge to level of hinder border of orbit; this groove median anteriorly, but (doubtless an individual peculiarity) posteriorly curving somewhat towards right orbit, the asymmetry thus introduced permitting of much more definite development on left than on right side of a largish fan of striae diverging from near posterosuperior border of orbit. Occiput and nape not, or barely, elevated: feeble occipital and nuchal crests, former about half latter, which is subequal to eye. Opercle moderately inflated; bounded above and in upper half of hind margin by a well-defined ridge, but wholly devoid of a horizontal keel or ridge on its surface. Gape almost vertical.

Trunk with 20 subequal annuli; somewhat compressed; shallower from about 3rd to about 6th annulus than elsewhere; depressed also for several annuli on either side of 13th. Seven trunk ridges; superolaterals (dorsolaterals), mediolaterals, midventral ending on 6th caudal, beginning of 1st caudal, front of last body, scute, respectively: inferolaterals (ventrolaterals) continuous with corresponding ridges of tail. Dorsal surface slightly, superolateral surface very slightly, convex; other surfaces virtually plane. At middle of trunk dorsal surface is subequal in transverse extent to superolateral, slightly greater than ventral, about one and one-third times inferolateral, surface. Lateral surfaces meet at about 140, ventral at about 130, degrees.

Tail with 44 annuli: in cross section trapezoidal, height slightly exceeding ventral width, which distinctly exceeds dorsal width; surfaces virtually plane, except ventral, which is gently convex. Upper ridge originating near front of last body scute (thus overlapping mediolateral trunk ridge by nearly one annulus-width), a trifle nearer superolateral than mediolateral ridge of trunk; attaining dorsal profile at 8th caudal annulus. Lower ridges continuous with, but shortly behind vent wider apart than, lower trunk ridges.

Dorsal moderate; with 28 rays, the longest (middle) subequal to horizontal extension of two thoracic annuli; base not distinctly elevated,

on 2·8 trunk and 7·0 caudal annuli, subequal in length to combined eye and snout: length to origin 2·6 in standard length, or 3·6 its own base. Pectoral with 18 rays, longest three-fourths eye; free margin rounded; base wide, oblique, not prominently ridged, rather shorter than longest ray. Anal minute. Caudal with 6 rays; length exceeding eye-diameter; pointed.

Extensively and completely sculptured; chief motifs, fan, double fan or spindle, rotula, festoon. In trunk, on dorsal surface each annulus with about 8-10 well-marked ridges, the middle 3 or 4 tolerably straight, the rest increasingly bowed outwards, the whole pattern suggestive of a blunt achromatic spindle, with equator along main anteroposterior axis of fish; a curved longitudinal ridge, exhibiting varying degrees of development in different annuli, crossing scute near, but not necessarily at, middle; annuli separated by stout ridges, most with some traces of mesial thickening, the first four with a central segment convex cephalad, the rest mainly convex caudad: on superolateral surface a rather less clearly defined spindle in each annulus, with, between successive spindles, a variously shaped, usually more or less elliptical shield, embossed centrally with a delicate rosette or rotula; a raised longitudinal line, festoon-like but convex upwards, in each annulus, lying in early and late annuli towards superolateral ridge, in other annuli near middle of pattern: on superolateral surface a broad-based upright fan; interfan shields bearing a series of spokes with or without clearly marked circular rim; fans delimited above by an inverted festoon, the annulus-wide arcs transgressing the mediolateral ridge in the middle annuli, but falling below it in the anterior and posterior body rings: on ventral surface each annulus with an escutcheon traversed longitudinally by midventral trunk ridge and crossed by a dozen transverse ridges, the anterior concave cephalad, the posterior concave caudad; at each end of line of junction between successive escutcheons a triangular or rounded buckler, delimited by well-developed ridge, and usually bearing a few radiating ridges; below, and largely hidden by, escutcheons a transverse spindle, extending in hinder annuli, where escutcheons are narrower, well beyond lateral borders of latter. In tail behind dorsal, each surface with a more or less clearly defined spindle, the pattern tending to become less evident caudad; a rotula-embossed shield between spindles on lateral surface, not, or obscurely, present on other surfaces. Nuchal shield with a subelliptical group of ridges in two fans flanking the keel: on occiput a smaller hexagonal area of radiating ridges, embracing the keel, and preceded by a still smaller median rosette. Interorbital region with some longitudinal ridging and a small amount of pitting. On lateral surface of snout four rosettes, the first (smallest) and second tolerably complete, third (largest) with inferior moiety much more extensive than superior, fourth, below nostril, an imperfect fan.

Collector observed of living specimen, 'a brown pipefish . . . looks like a piece of drift kelp'. The coloration following preservation in alcohol is as follows. Trunk (except near pectoral base) and tail without pronounced markings. Trunk with dorsal surface light, somewhat greenish brown; lateral surface above mediolateral ridge a shade lighter, less greenish than dorsal surface, below ridge lighter still;

ventral surface mostly fawn, a trifle more yellowish towards head, and darker, somewhat greenish yellow round 15th-17th annulus. Tail with dorsal surface approximately concolorous with that of trunk; lateral surface brownish fawn, lighter than any part of side of trunk; ventral surface pale, somewhat silvery fawn; longitudinal ridges darker, brownish. Nape and occiput concolorous with dorsal surface of trunk; dorsal surface of snout rather more dusky; two small obscure dark patches near middle of interorbital: side of head in general concolorous with flank; snout distinctly more dusky; lighter below eye; opercle greenish, somewhat silvery: ventral surface below eye silvery, with some median greenish, becoming dusky greenish on snout. Iris blackish externally; an ill-defined pinkish annulus surrounding pupil. Dorsal membrane translucent, faintly greenish; small patch of minute greenish chromatophores at base of majority of rays; borders of rays slenderly outlined in blackish, but body of ray virtually concolorous with membrane. Pectoral membrane almost colorless; one or both borders of each ray defined by very narrow dark-brown line. Caudal pale greenish in proximal one-third, becoming increasingly dusky distally.

The only notable color marking in the specimen as preserved is a pair of conspicuous reddish brown stripes running longitudinally along side of face, just on to trunk. Beginning near ventrolateral edge, shortly behind middle of snout, the two lines, whose summed width is subequal to their distance apart, run parallel and nearly straight backwards and upwards to meet orbit at about 8 o'clock (left eye) : from 4 o'clock on posterior orbital border they continue across middle of opercle, straight and parallel save at anterior opercular margin, where they briefly divaricate: beyond opercle they extend uninterruptedly, as a short loop, on to first thoracic annulus, terminating on pectoral base. For most of their length stripes are of equal intensity, but anteriorly on snout the upper is better developed.

Dimensions.—Standard length 159·2 mm., total length 162·8. Length to origin of pectoral at front of base 25·0, at middle of base 26·5, to origin of dorsal 61·6; to termination of adpressed pectoral 27·6, of dorsal base 78·9; to vent 66·0. Head 24·8, snout 15·0, eye 2·7, interorbital 1·8. Depth (and, in brackets, width) at middle of snout 2·3 (1·8), front of eye 3·4 (3·3), opercular margin 5·0 (3·7), vent 4·9 (3·8), middle of tail 2·9 (2·6), origin of caudal 1·1 (0·9) : maximum 5·1 (4·1) at 16th (18th) annulus, about 58 (63) behind tip of snout; the maximum depth of trunk (5·1) being equalled at level of back of eye if measurement includes mental prominence. Length of pectoral base 1·8, longest pectoral ray 2·1, longest dorsal ray 3·6.

Type Material.—Described and figured (Plate I, Fig. 2) from the unique holotype, collected by Mr. Bruce Mollison; deposited in the Queen Victoria Museum, Launceston: Reg. No. 1954.5.2.

Type Locality.—Off Bivouac Bay, Tasman Peninsula, south-eastern Tasmania; 25 fathoms; clean sandy bottom; 29th March, 1953; 'came up fastened to handline': other fish secured by Mr. Mollison's boat, working from Fortescue Bay, included '70 lbs. of flathead, box of perch, gurnet, cod . . . 6 doz. barracouta (and two squid)'; also one specimen of *Parapercis allporti* (Günther, 1876).

Discussion.—Four Australian species of *Syngnathus* Linné, 1758 are recorded in the check-List (McCulloch, 1929); of which one, *S. pelagicus* Linné, 1758, is doubtful, the entry apparently being based on a misidentification—*cf.* Waite & Hale (1921)—by A. Zeitz (1908: 298) of some of Verco's material from Spencer Gulf. From these and the subsequently-described *S. tuckeri* the new species may be separated by the subjoined key. Recent fission of *Syngnathus* as understood by McCulloch would distribute *S. curtirostris* Castelnau, 1872, *S. tigris* Castelnau, 1879, *S. superciliaris* Günther, 1880, *S. tuckeri* Scott, 1942, to *Pugnaso* Whitley, 1948, *Tigricampus* Whitley, 1936 (via *Yozia* Jordan & Snyder, 1801) *Filicampus* Whitley, 1948, *Mitotichthys* Whitley, 1948, respectively—each of these genera apparently being, at date of publication, monotypic.

Key to Australian Species of Syngnathus Linne, 1758

A. Mediolateral trunk ridge descending near vent to become continuous with ventrolateral tail ridge. Dorsal about equally on trunk and tail.
  B. A filament above each eye. Snout = post-orbital head. Annuli about 58. Trunk and tail without ocellate markings .... *S. superciliaris*
  BB. No filament above eye. Snout > postorbital head. Annuli about 53. Each annulus of trunk and tail with a more or less distinct lateral ocellus .... *S. tigris*

AA. Mediolateral trunk ridge not continuous with ventrolateral tail ridge; terminating on side of trunk at about level of vent. Dorsal not equally on trunk and tail.
  C. Dorsal mainly on trunk; rays > 33. Trunk annuli > 22. Subdorsal annuli > 11 .... *S. tuckeri*
  CC. Dorsal mainly on tail; rays < 33. Trunk annuli < 22. Subdorsal annuli < 11.
    D. Trunk annuli < 39. Total annuli < 55. Opercle with faint horizontal ridge anteriorly .... *S. pelagicus*
    DD. Trunk annuli > 39. Total annuli > 55. Opercle devoid of horizontal ridge.
      E. Snout < ½ head. Head 3-4 in trunk. Dorsal base 3-4 in trunk. No brown facial stripe .... *S. curtirostris*
      EE. Snout > ½ head. Head 1-2 ($1\frac{2}{3}$) in trunk. Dorsal base 2-3 ($2\frac{2}{3}$) in trunk. Double brown stripe on hinder snout and opercle .... *S. mollisoni*

From the New Zealand *S. norae* Waite, 1911, with which it has much in common, including a longitudinal brown face marking, *S. mollisoni* differs notably in lacking the former's characteristic color pattern on trunk and tail, and in having 10-12 more dorsal rays, but some 4-7 fewer trunk annuli. Of the four Australian species of *Leptonotus* Kaup, 1853 (in which only females differ trenchantly from *Syngnathus*), three—*L. blainvillianus* (Eydoux & Gervais, 1837), *L. caretta* (Klunzinger, 1879), and *L.* (*Kaupus*) *costatus* Waite & Hale, 1921—differ at sight from *S. mollisoni* in having snout less than half head, and head twice, or more than twice, in trunk; while compared with *L. semistriatus* Kaup, 1856, with which it agrees in many points, our form has 10-12 fewer dorsal rays and 3-5 fewer trunk annuli. *S. mollisoni* makes a rather close approach to *Corythoichthys pœcilolæmus* (Peters, 1869)—which has been referred by Whitley to *Parasyngnathus* Duncker, 1915—but is clearly distinguished from that species by the two main features in respect of which *Syngnathus* and *Corythoichthys* have commonly been

held to stand in contrast: the new species wholly lacks the opercular ridge, and it is of decidedly more slender habit, having maximum depth of trunk proper 3·5 in dorsal base, 1·4 in postorbital or 5·0 in total head, and equal to anteroposterior extent of about 2·5 thoracic annuli, compared with 2·0-2·3, 1·0-1·1 or 3·5-3·9, and about 3·0-3·5; further, neither species shows any of the markings occurring in the other.

Remarks.—The species is named in honour of the collector, Mr. Bruce Mollison. Mr. Mollison has noted a curious habit shown by this fish of which I do not recollect any mention in the literature. Amplifying an entry in his diary, 'clicks head backwards like a flip-beetle', he observes in a letter, 'That pipefish "clicked" happily long after I caught him—jerking his head stiffly backwards and then slowly forwards, and so on in a really foolish manner that it gave one a headache to see'. An accompanying series of four rough sketches shows: first, pipefish with head (and neck?) bent sharply back virtually at a right angle with trunk—with notation 'click'; second, head and trunk in normal relative positions; third, fourth sketches like first, second. There is of course at the moment no evidence available as to whether this behaviour-routine is a specific characteristic or merely an individual or pathological pecularity. In the preserved specimen the anterior 35 mm. or so (*i.e.*, to about 4th annulus) can be bent back fairly readily till it is normal to the rest of the fish.

Family LEPIDOTIDAE (BRAMIDAE *olim*)

Genus **Lepidotus** Asso, 1801

Lepidotus squamosus (Hutton, 1875)

Toxotes squamosus Hutton, 1875, Ann. Mag. Nat. Hist. (4), XVI: 313. Type locality: Cook Strait, New Zealand.
[*non*] *Sparus raii* Bloch, 1791, Nat. ausl. Fische, v: 95, pl. CCLXXIII. Type locality: Northern Seas [= England].
Brama raii (Bloch). Castelnau, 1879, Proc. Linn. Soc. N.S.W., III: 352. McCulloch, 1929, Mem. Aust. Mus. Sydney, v, 11: 194. And Australian authors generally.
Brama rayi (Bloch). McCoy, 1887. Prodr. Zool. Vict., dec. XIV: 127, pl. CXXXIII.
Lepidotus squamosus (Hutton). Whitley, 1938, Aust. Zool., 9, 2 : 193.

Status.—Ray's Bream (named after John Ray), or the Pomfret, is usually called *Brama raii* (Bloch, 1791), and its few Australian appearances have been recorded under this name. Whitley (1938), who has devoted a paper to this species and its allies in Australia, considers there is a distinct Australian and New Zealand form, which should be known as *Lepidotus squamosus* (Hutton, 1875).

Tasmanian Records.—In July, 1953, Mr. J. B. Ralston, Mowbray Park, Mella, forwarded to the Queen Victoria Museum, Launceston, for identification photographs of a fish caught south of Temma, West Coast, during April: the specimen, which weighed about four pounds, appeared to be stranded in about a foot of water, and was caught with a knife. From an examination of these photographs and from consideration of additional information supplied by Mr. Ralston in reply to a questionnaire, there seems little doubt the fish was this species.

On 27th November (after the above record had been made in the MS of the present paper) there appeared in the Launceston *Examiner* a report, accompanied by a photograph, of a second specimen, obtained by the *Liawenee*, the research vessel of the State Fisheries Division.

In response to an inquiry regarding the most convenient procedure in making a record of the occurrence of this species in our waters, Mr. M. M. Hodgson, Biologist, Fisheries Division, Department of Agriculture, has expressed the wish that the two captures should be noted in the present account, and I am indebted to his courtesy for the following details about the second example: caught on a long line in 250 fathoms E.S.E. of Fortescue Bay, Tasman Peninsula, 20th November, 1953; length to caudal fork 520 mm.; preserved in freezer on board the vessel, and later donated to the Tasmanian Museum, Hobart.

Remarks.—The species, which is rare and sporadic, has been recorded from New South Wales—a record by Castelnau, the validity of which was doubted by McCulloch (1927); Victoria, where it occurred in considerable numbers in April, 1884 (McCoy, 1887): Lord Howe Island; New Zealand: the capture, within a few months, of two examples in Tasmanian waters is of interest.

Family CLINIDAE

In a previous key (1939) the local Clinidae as then known are diagnosed along with the Blenniidae. The invalidation of the entry there given for '*Clinus johnstoni*' consequent upon the recognition of this fish as a *Petraites* (see below), and the addition here of a new species of *Clinus* render expedient the provision of a revised synopsis. (In the 1939 key number of spines in second dorsal of *C. perspicillatus* appears as XXII-XXIV, a misprint for XXXII-XXXIV.)

In the subjoined synopsis entries marked * are valid for Tasmanian, but not necessarily for all Australian, species.

Key to Clinidae Recorded from Tasmania

A. Three distinct dorsal fins: first spinous (III), second spinous (XIV-XVI)*, third soft (10-12)*. Lateral line with anterior section running parallel to dorsal profile to below third dorsal (*i.e.*, for about half standard length); a posterior section, if present, separate, in the form of a secondary series of incised scales extending from caudal base along middle of tail.

B. Head naked .... *Tripterygion*

[D. III, XVI, 11. A. 23. Teeth villiform; several in maxilla caniniform. Total length about 75] .... *T. clarkei*

BB. Head scaly .... *Gillias*

[D. III, XIV, 10-12. A. I, 21. Teeth in jaws subequal] .... *G. macleayanus*

AA. Two dorsal fins, separate or connected by membrane: first spinous (III), second mixed (XXVI-XXXVII, 3-8)*. Lateral line continuous: with an anterior segment in upper one-fourth of side, subparallel for about one-fourth standard length, then dipping down, behind pectoral, and continued (with more widely spaced pores) along mid-flank to caudal peduncle.

C. First dorsal spine inserted over, or in front of, eye. Orbital tentacle long, simple. Minimum depth of caudal peduncle $< \frac{1}{2}$ its length (from anal membrane to level of hypural) *Cristiceps*

[First spine behind middle of eye, about twice third spine. D. III, XXVI-XXIX, 6-8. A. II, 24-26. Total length about 100] .... *C. australis*

CC. First dorsal spine inserted behind eye. Orbital tentacle with some lobes*. Minimum depth of caudal peduncle $> \frac{1}{2}$ its length (measured as for C).

D. Membrane of third dorsal spine free of first spine of second dorsal or connected only to its base. Ventral origin behind last spine of first dorsal*. Maxillary to about level of hinder margin of orbit or beyond it*. Total length about 250-400* .... *Petraites*

E. First dorsal spine > third spine, about twice first spine of second dorsal, ≤ ½ longest ventral ray. Maxillary to, or nearly to, posterior margin of orbit. Tentacle of anterior nostril minute (≤ ⅓ of orbital tentacle), not reaching to lip; carried towards eye, falls far short of orbit. Orbital tentacle slender, elongated, with a few small lobes; adpressed, reaches first dorsal spine. Teeth behind anterior villiform patch cardiform in both jaws; in upper jaw about 14-18 behind each villiform patch. Depth of caudal peduncle about = its length (see C). D. III, XXVIII-XXIX, 4-5. A. II, 23-24. Total length about 275 .... *P. forsteri*

EE. First dorsal spine ≤ third spine, subequal to first spine of second dorsal, about = longest ventral ray. Maxillary to beyond posterior margin of orbit. Tentacle of anterior nostril large (about = orbital tentacle), tubular, surmounted by about 6 long filaments overhanging mouth; carried towards eye, reaches orbit. Orbital tentacle broad, much branched; adpressed, reaches about halfway to first dorsal spine. Teeth behind anterior villiform patch caniniform in both jaws; in upper jaw about 5-8 behind each villiform patch. Depth of caudal peduncle about = ½ its length (see C). D. II-III, XXXII-XXXIV, 5-6. A. II, 25-27, Total length about 400 .... *P. johnstoni*

DD. Membrane of third dorsal spine connected to about middle (or slightly below middle?) or to upper half of first spine of second dorsal. Ventral origin in advance of last spine of first dorsal.* Maxillary to about level of middle of eye. Total length about 50-100* .... *Clinus*

F. First dorsal connected to about middle of first spine of second dorsal. Orbital tentacle large, with about 5 fingerlike processes. Pectoral to level of vent. D. III, XXII-XXXIV, 3-5. A. II, 24-26. Total length about 100 .... *C. perspicillatus*

FF. First dorsal connected to top of first spine of second dorsal. Orbital tentacle small, with 1 or 2 minute flat lobes. Pectoral fails to reach level of vent. D. III, XXXV-XXXVII, 5. A. 11, 29. Total length about 50 .... *C. puellarum*

Genus Petraites Ogilby, 1885

Petraites johnstoni (Saville-Kent, 1866)

Clinus johnstoni Saville-Kent, 1866, Rept. Fish. Dept. Tasm., 1866 : 13. Type locality: Adventure Bay, Tasmania.

Clinus johnstoni Saville-Kent. Saville-Kent, 1867, Pap. Proc. Roy. Soc. Tasm., 1886 : XXXIV and 121. Johnston, 1891, Pap. Proc. Roy. Soc. Tasm., 1890 : 33. McCulloch, Proc. Linn. Soc. N.S.W., XL, 2, 158 : 273, pl. XXXVII, fig. 2. Scott, 1935, Pap. Proc. Roy. Soc. Tasm., 1934 : 69.

Status.—McCulloch (1915), with two specimens 227, 341 long before him, stated 'membrane from last [spine of first dorsal] extends about one-third up the spine of the second dorsal'. In three individuals of standard length 239, 297, 353 I find first spine of second dorsal measures 17·4, 19·0, 10·3, while membrane from first dorsal extends 4·6, 5·0, 3·8 up spine, *i.e.*, for 26, 26, 37 per cent of spine-length.

The relations between *Clinus* Cuvier, 1816, *Cristiceps* Cuvier & Valenciennes, and *Petraites* Ogilby, 1886, which last was proposed—following a suggestion by Macleay (1882 : 20)—to accommodate the species 'which oscillate between the two [other] genera', are not very satisfactorily defined. The question has been discussed by McCulloch (1908), who suggested that species with first dorsal spine over, or in front of, eye should be placed in *Cristiceps*, while species with that spine behind eye should be referred to *Petraites* if third spine is connected to 'basal portion only' of first spine of second dorsal, and to *Clinus* if the connexion is to 'the middle or upper half'. In the orthotype of *Petraites*, *P. heptæolus*, however, the first dorsal at times barely reaches the second dorsal, and the scope of the genus probably could profitably be extended to cover all stages between, and including, connexion up to first half of dorsal spine and non-connexion.

McCulloch's observations together with the fresh data cited above make it clear that Saville-Kent's fish, hitherto regarded as a *Clinus*, is really a *Petraites*.

With a number of the Clinids described early remaining unrecognised, our knowledge of the group is still somewhat sketchy: but it begins to look as if in *Cristiceps* the first dorsal is elevated, in *Clinus* not elevated, above the second dorsal, with *Petraites* here also ambivalent.

Genus **Clinus** Cuvier, 1816

Clinus puellarum *sp. nov.*

(PLATE I, FIGURE 1)

Diagnosis.—In general facies approaching *C. perspicillatus* Cuvier & Valenciennes, 1836. D. about XXXVIII-XL (III, XXXV-XXXVII), 5. A. about II, 29. First dorsal originating slightly behind posterior border of preoperculum; its spines subequal, not noticeably higher than anterior spines of second dorsal, its membrane joined to top of first spine of second dorsal, the free margins of the two fins continuous, with a very slight dip above 'interdorsal': rays somewhat elevated above spines, 3rd, 4th, 5th a trifle closer together than 1st, 2nd, 3rd; last united by membrane to caudal base. Membrane of anal moderately incised; briefly attached to caudal peduncle. Orbital tentacle small; surmounted by one or two small flat lobes. Tentacle of anterior nostril with one flat appendage. Teeth in both jaws in an anterior patch, followed by a single row; all teeth subequal, no outer caniniform row in upper jaw: vomerine patches not contiguous. Maxilla to below about middle of eye. Interorbital more than half diameter of eye. Adpressed pectoral fails to reach level of vent. Interval between middle of vent and hinder base of ventral exceeds length to latter point. Head and trunk in general more or less uniform brown, with some lighter areas below dorsal base: no recognizable cross bars, no dark spot below first dorsal. Apparently small (*ca* 50 mm.) Tasmania.

Description of Holotype.—B. 6. D. XL (III, XXVII), 5. A. II, 29. P. 13. V. I, 3 (spine hidden). C. 12 + ⅝. Myotomes *ca* 16 (12 postpectoral) + 36, last few highly angulate. Standard length 1·1 in total length. Maximum depth, occurring about level of 3rd anal ray, 5·8 in standard length, subequal to length to origin of dorsal; depth at vent 6·0 in standard length, slightly exceeding length to insertion of ventrals.

Head to end of operculum (hereinafter, 'bony head') 4·3 in standard length, one-fourth length to anal termination; head to end of opercular flap ('total head') 3·9 in standard length, less than half anal base. Eye 4·4 in total head. Snout without lips ('simple snout') 1·7, total preorbital length ('full snout') 1·2, in eye. Interorbital 1·7 in eye (horizontal diameter). Length to vent 2·5 in standard length, slightly exceeding thrice postorbital bony head. Depth of caudal peduncle 4·1 in bony head, equal to eye, subequal to distance from base of last dorsal ray to level of hypural joint. Total head, trunk, tail 26, 15, 59 per cent of standard length.

Trunk and tail elongate, compressed. Width immediately behind pectoral base, at vent, at middle of caudal peduncle 1·5, 2·0, 8·0 in depth at these points. With general sense of dorsal profile horizontal, ventral profile descends tolerably evenly to just beyond vent, after which it rises in a curve of increasing steepness: caudal peduncle tilted upwards, bringing tips of highest caudal rays about to level of tips of dorsal rays. (Some upturning of caudal peduncle is not uncommon in formalin specimens—usually not present, or slight, in spirit material—of *Clinus perspicillatus*: and in present species peduncle is probably carried more or less horizontally in life.)

Head subconical: width at front of eyes 3·0 in total head, slightly less than depth there, subequal to distance from lowest point on orbit to tip of orbital tentacle; at level of dorsal origin 1·8 in total head, slightly less than depth there, subequal to extension beyond opercular angle of first segment of lateral line. Simple snout short, subequal to distance from tip of maxilla to orbit: viewed laterally, gently convex; viewed superiorly, bluntly rounded. Mouth moderate, oblique, its cleft at about 30 degrees to the horizontal: upper lip large, tumid, bounded above by deep sulcus; extending beyond tip of simple snout by more than half its own shortest distance from orbit; rounded, but scarcely expanded, free end of maxillary reaching to below 0·4 of eye: lower lip less tumid than upper, but projecting slightly beyond it. Eye moderate; wholly in anterior half of total head; not cutting dorsal profile. Interorbital decidedly less than eye; strongly convex, but with mesial longitudinal depression, extending from level of pore between anterior and posterior nostrils to level of orbital tentacle. Gill-covers expanded; united for two-thirds of their anteroposterior extension, almost to insertion of ventrals; forming a free fold across isthmus. Gill-openings large, more than thrice height of pectoral base; separated by less than eye-diameter. Preoperculum with upper posterior margin subcutaneous; its angle, up to just beyond which it is free, broadly rounded. Operculum unarmed: its fleshy lobe broad, falcate. Anterior nostril tubular; its height about twice its anteroposterior, which somewhat exceeds its transverse, diameter; surmounted posteriorly by a single simple ovate or obovate lobe, subequal in length to anteroposterior axis of supporting tube, directed upward, forward, slightly inward; the total height subequal to width of upper lip; inserted between 9 and 10 o'clock, relative to middle of eye (left side); about thrice as far from orbit as from anterior margin of preorbital: internarial distance subequal to distance from nostril to orbit Posterior nostril a very short backwardly and inwardly directed tube,

the anterior wall decidedly oblique, much longer than posterior wall; located at a little earlier than 11 o'clock, its distance from its fellow subequal to its distance from anterior nostril, and to its distance from orbital tentacle. Orbital tentacle at top of orbit, its origin slightly nearer to tip of full snout than to origin of dorsal; its base inserted almost wholly on the eye itself, the anterior line of attachment running inward and very slightly forward; compressed, along main axis of fish, to paper-thinness; length about thrice base, subequal to total length of anterior nostril: left tentacle cleft for about half its length into two subequal erect, moderately pointed lobes; right tentacle with one large falciform outer lobe, with at its base a minute inner lobe (result of injury?).

Teeth in upper jaw comprise, on each side: first, an anterior elongated subtriangular patch (outer margin curved to follow line of jaw), separated from its fellow in other half of jaw by about twice a tooth interval, extending to just beyond middle of jaw, its maximum width about one-fourth its length, the teeth stout, conical, some somewhat recurved, widely spaced, about 12 in outer row, about 10 in inner row, and about 12-14 in from one to (anteriorly) three irregular others rows; secondly, from posterior angle of patch a single row of about 6. All teeth in upper jaw subequal; no outer caniniform row. Mandibular teeth in each ramus: first, an elongate ovoid group, virtually continuous at its anteroexternal tip with its fellow, extending for two-fifths of length of jaw, comprising about 12 teeth, in part in three rows; secondly, a following line of 3 or 4: teeth in lower jaw subequal to one another and to those of upper jaw. Vomerine teeth standing on, but not defining the outline of, two ovate-acuminate slightly raised granular regions, widest internally, each about one-fourth as long as one dentigerous triangle of jaw; these patches just contiguous, but nearest teeth of the two elements well apart: each set of 6-8, subequal to one another, a little more widely spaced, and a trifle larger, than those of jaws.

A deep frenum across upper jaw, extending mesially to level of vomer, laterally to behind last tooth, its free margin deeply excavate; beset with numerous dermal tubercles, subequal in size, and more or less similar in shape, to teeth. Tongue largely adnate; narrowing anteriorly to form a partly free, rather bluntly rounded lobe, its width, which is about one-third maximum width of tongue, somewhat less than its length: whole upper surface with closely-set papillae, extending, in adnate portion, just on to lateral surfaces, so that, viewed from above, outline here becomes denticulate.

Head with numerous open pits, including, on each side: circumorbital ring of 7, anterior preorbital arc of 3, infraramal line of 4, preopercular series of 7 comprising short upper arc of 3 and longer lower arc of 4, 2 upper genal immediately in advance of upper preorbital, 5 running from behind anteroposterior border of eye to near origin of lateral line and thence forward and upward towards dorsal profile shortly in advance of level of first dorsal spine: also one median nuchal pore. Lateral line comprising a short conspicuous earlier superolateral segment and a long inconspicuous later mediolateral segment. Anterior segment originating just behind level of 2nd dorsal spine, proceeding in an arc, gently convex upward, to level of 11th spine of combined dorsal, and then running down and back in a spur of several tubercles; nearest approach to dorsal profile,

occurring above hind border of pectoral base, equal to half maximum departure of non-spur portion from dorsal profile; tubercles well-marked, heavily pigmented mounds, with basal diameters subequal to their interspaces; pores 25 on left side, 24 on right, one to each mound, always with some rim (usually crenulate), and in larger, more anterior tubercles with distinct chimneys; modal diameter of pore 120 μ, mean pore-interval 380 μ. Posterior segment scarcely recognizable without lens; pores not in mounds, without noticeably elevated rims; an oblique downward series of 4 from end of anterior segment, the last below 14th dorsal spine; thereafter a mediolateral series of about 38 to near caudal base, the later ones very small.

Covered everywhere, except on head, nape, inner pectoral base, with small cycloid scales, more or less buried in skin: in closely set, sometimes contiguous, but not or barely imbricating, rows on most of trunk and tail, but less densely, and more irregularly disposed towards, and on, caudal peduncle, where area of interspace may exceed area of scale: sc.l., approximately 150; sc.tr., at level of end of adpressed pectoral, about 10 to tip of anterior segment of lateral line, followed by about 30, but exact counts scarcely practicable.

The superior margin of the dorsal fin is so nearly continuous throughout that if continuity of membrane be taken as the criterion of unity it can be regarded as a single fin: at the same time, the 3rd-4th spine interval, though small, exceeds any other interspine distance, and can be regarded as the characteristic interdorsal of the genus.

Dorsal treated as single fin: length to origin 1·5 in total head, subequal to depth at vent; first spine inserted very slightly behind level of hinder border of preoperculum, equidistant from tip of opercular lobe and base of orbital tentacle; base 1·1 in standard length; lengths of spines (without membranous pencils) subequal in first 6 (3rd $>$ 1st: 4th $>$ 5th $>$ 2nd: 6th; shortest $=$ 1·1 longest), about an eye diameter, thereafter increasing regularly, with 20th spine 1·3, 40th (last) 1·9, times 1st; anterior spines differentially spaced, the 2nd, 3rd, 4th, 5th interspaces (spine-base to spine-base) being 1·6, 2·0, 1·5, 1·5 times 1st interspace; membrane dipping very slightly anteriorly, lowest between 4th and 5th spines, where its minimum oblique height, measured parallel to these spines, is 0·8 of their mean length, or 1·1, 1·2 in corresponding measurements for membranes linking 3rd and 4th, and 1st and 2nd spines; tips of all spines with backwardly directed pointed membranous pencils; rayed portion of fin elevated somewhat above spinous portion, its longest (3rd) ray 1·4 longest (40th) spine, its base about two-fifths its maximum oblique height; 3rd, 4th, 5th rays equidistant, their intervals a trifle less than intervals between 1st, 2nd, 3rd, which are equal *inter se* and to those between posterior spines; last attached to base of caudal by membrane extending behind level of hypural by about length of anterior nostril; tips with membranous lobes broader than those of spines.

Dorsal treated as two fins: base of first 24·1 in base of second, equal to simple snout; interdorsal 1·4 in first dorsal base, about half depth of caudal peduncle: second dorsal originating at level of confluence of superior margin of opercular lobe and auriform end of subvertical post-pectoral fold, length to its first spine 3·6 in its own base, subequal to interval between hinder aspect of ventral base and middle of vent.

Anal fin originating below 15th spine of combined dorsal, length to its origin 2·4 in standard length, half base of composite dorsal; terminating about one eye-diameter in advance of dorsal termination; base 1·8 in standard length; behind the two shortish spines, fin subequal in height, somewhat higher than dorsal, to within last half dozen rays, which are somewhat elevated, the local increase in height thus paralleling increase of rayed over spinous dorsal; membrane markedly incised anteriorly, only shallowly excavate posteriorly; last ray joined to caudal by narrow slip of membrane.

Pectoral fin somewhat pointed; length to its origin 4·4 in standard length; all rays simple; membrane excavated moderately between upper rays, boldly between lower; longest (6th) ray 7·5 in standard length; adpressed fin extending to below 12th dorsal spine, failing to reach level of middle of vent by more than half an eye-diameter. Ventral fins almost contiguous basally, inserted very slightly in advance of level of first dorsal spine; length to origin 6·4 in standard length; extending about two-thirds of distance from origin to vent; estimated length of spine, hidden in flesh, 3·3 in total head; 1st and 2nd rays 2·1, 1·5 in total head, conjoined for more than half length of longer; 3rd (innermost) ray small, weak, 7·6 in bony head, free for about one-sixth of its length. Caudal somewhat obliquely truncate; all rays simple, upper slightly longer than lower; longest (4th, 5th) 1·8 in total head.

Sides of trunk and tail in general almost uniform dark-brown, with a hint of purple; a trifle lighter, more reddish behind pectoral base: at six points along dorsal profile, immediately subtending fenestrae in fin, small irregular regions in which color is somewhat lighter: ventral surface of trunk mid-brown, rather paler, more reddish anteriorly, touched with purplish posteriorly; brownish white at vent; ventral surface of tail, which is scarcely wider than anal base, concolorous with flank. Side of head brown, about concolorous with flank superiorly, progressively lighter inferiorly; in much of lower half delicately vermiculated with pinkish fawn and pinkish grey; a little more ferrugineous below and behind eyes: two short indefinite darkish spokes from orbit, round 2 and 4 o'clock (left side), a more obscure dark patch near 9 o'clock. Eye dark purplish; a lunule of pinkish brown concentric with much of lower, and part of anterior, border of orbit. Dorsal surface of head mostly dark-brown; an ovoid lighter occipital patch, partly bordered laterally by upper postorbital dark spoke. Ventral surface of head greenish brown, palest along borders of isthmus. Branchiostegal membrane pale, almost translucent greyish. Anterior nostril and its distal lobe flesh colored, minutely punctulated with brownish. Orbital tentacle pale brownish, approaching flesh; blotched proximally with dark-brown.

Membrane of dorsal in general dark, somewhat reddish brown, pigmentation more intense and net result less ferrugineous caudad: in second dorsal six irregular fenestrae, the earlier light orange, the later pale amber, occurring approximately at interspinous intervals 1·0-2·5, 6·0-7·5, 12·0-13·5, 19·0-20·5, 27·5-29·5, 35·0-36·0, decreasing in size, particularly in vertical extent, caudad: in first dorsal pigmentation greatest in 1st, least in 3rd (interdorsal) spinous interval: whole fin, especially in posterior half, lighter proximally than distally; dark, almost black blotches between outer halves of rays, the markings progressively decreasing in size and intensity, traceable cephalad for one-third length of fin,

or more: indications in places of a narrow orange marginal band: spines and rays silvery, their color largely hidden by the sheathing membrane; their distal pencils white. Membrane of anal dark-orange, very heavily punctulated with blackish brown; a dark stripe, widest distally, behind each ray, the marking best developed posteriorly; tips of rays white. Pectoral membrane with ground color very pale, translucent: upper 4 or 5 rays greenish in basal one-third, thereafter almost colorless; other rays pale greenish, the color deepest in middle rays; whole base blotched heavily with dark-green, involving about one-third of upper, half of middle, more than half of lower, rays; traces of two or three greenish cross bars on central, scarcely distinguishable on upper, rays. Ventral with first (innermost) ray grey, minutely blotched, except on ashen tip, with brownish green: other rays dark greyish lavishly mottled with green up to, and slightly beyond their bifurcation, just below which the green shows indications of forming a darker ring, and beyond which a gradual decrease and final cessation of the pigmentation leaves about one-fifth of whole length clear, faintly pinkish; a small whitish spot on inner surface of base, thrice its own diameter from insertion of fin. Caudal membrane dark-brown, virtually uniform except for distinct white subtriangular patches at tips of rays and basal subcircular whitish spot: rays concolorous with, or slightly darker than, membrane proximally, darkening distally to become, in middle rays, almost black.

Differences Exhibited by Paratype.—A paratype agrees in general fairly closely with the rather larger holotype. Chief differences: (*a*) two fewer spines in second dorsal (D. III, XXXVII, 5); (*b*) maxilla to 0·6 of eye; (*c*) caudal less elevated, longer absolutely, 5·7 in standard length; (*d*) coloration a great deal lighter, the ground color yellowish brown punctulated profusely with reddish brown and blackish, some elements of color pattern obscure or indistinguishable. The marked difference in general color between holotype and paratype is attributable primarily to the degree of expansion of the chromatophores, which are contiguous or virtually so in former, but several times their own diameter apart in latter.

Dimensions.—The principal dimensions (in mm.) of the holotype are as follows. Standard length 52·0, total length 59·2. Head to end of operculum 12·2, to end of opercular flap 13·3. Eye 3·0; interorbital 2·0. Snout with upper lip 2·5, without 1·8. Length to middle of vent 21·1. Depth (and, in brackets, widths) at points specified: front of eye 4·6 (4·4), origin of dorsal 8·0 (7·5), immediately behind pectoral base 8·0 (5·5), vent 8·7 (4·3); maximum depth 8·9, at about 5 behind vent. Depth of caudal peduncle 3·0. Dorsal: lengths to origin, termination 8·6, 52·4; base of first dorsal 1·7, interdorsal 1·2, base of second dorsal 40·9; lengths of 1st, 2nd, 3rd spines of first dorsal 2·3, 2·5, 2·2, of 1st, 2nd, 3rd, 17th, 37th spines of second dorsal 2·3, 2·4, 2·5, 3·1, 4·3; interspaces of first dorsal 0·60, 0·95, interdorsal 1·20, first interspace of second dorsal 0·90; oblique heights of 1st, 3rd, 5th rays 5·8, 5·9, 4·0. Anal: lengths to origin, termination 21·7, 49·9; lengths of 2nd spine, 5th ray, 25th ray 3·0, 4·2, 4·8. Pectoral: length to origin 11·9; longest (6th) ray 6·9. Ventral: length to insertion 8·1; spine *ca* 4, 1st, 2nd, 3rd rays 6·1, 8·2, 1·6. Longest caudal ray 7·4.

Five scales: lengths 210, 280, 240, 270, 270, mean 254 μ; respective widths 180, 250, 190, 270, 270, mean 232μ.

Paratype: standard length 45·6, total length 53·6 mm.

Type Material.—The holotype was collected by Miss B. McCormick, Miss J. Paterson and Miss B. Townsend. It is deposited in the Queen Victoria Museum, Launceston: Reg. No. 1954.5.1. The single paratype, which was recognized as belonging to this species during the working-over of some general material in the Aldie Museum, the private museum of Mr. Peter Mercer, Launceston, was collected by Mr. Mercer. It will be offered to the Australian Museum, Sydney.

Type Locality.—The holotype was collected in a rock pool at East Beach, Low Head, Northern Tasmania, on 21st February, 1952: species associated with it included *Clinus perspicillatus* Cuvier & Valenciennes, 1836, *Volgiolus cardinalis* (Ramsay, 1882), *Pictiblennius tasmanianus* (Richardson, 1839) in adult and prepigmentation stages, *Alabes rufus* (Macleay, 1881). The paratype also came from Low Head.

Discussion.—Of the three species of *Clinus* Cuvier, 1816, recorded in the Check-List (1929), one, *C. marmoratus* Klunzinger, 1872 (type locality Port Phillip), does not seem to have been encountered by local workers; the others, *C. perspicillatus* Cuvier & Valenciennes, 1836, and *C. johnstoni* Saville-Kent, are known from Tasmania, the former also from Victoria and New South Wales (and—*fide* Waite (1923)—South Australia). Reasons have been given earlier in this paper for relegating *C. johnstoni* to *Petraites* Ogilby, 1885.

The new species differs from both *C. perspicillatus* and Saville-Kent's fish in the following features: membrane of first dorsal attached to top of first spine of second dorsal (to about middle, *C. perspicillatus;* to lower one-third, *C. johnstoni*) : more dorsal rays, 38-40 (*cf.* 35-37; 34-36), more anal rays, 29 (24-26, 25-26) ; orbital tentacle small, with one or two short leaf-like processes (in both, large, with four or more long lobes or processes) ; virtually uniform coloration of trunk and tail (about 8 cross bars, annulated dark spot under first dorsal; 8-9 dark cross bars, row of annuli below dorsal profile—the latter perhaps a development of the series of lightly pigmented areas in *C. puellarum*) ; pectoral fails to reach vent (to, or beyond, vent in both species).

Three specimens of *C. perspicillatus* of standard length 43·6, 48·5, 50·9 collected with the holotype of *C. puellarum* differ from it in having inter-orbital less than or equal to half eye, and interval between middle of vent and hinder base of ventral not exceeding length to latter point—but this second feature does not appear to characterize the standard figure of that species. (McCulloch, 1908).

The description of *C. marmoratus* Klunzinger, 1872, is not sufficiently detailed or precise to permit of its unequivocal recognition. *C. puellarum* appears to differ from it chiefly in exhibiting the following features: larger head, shallower body: earlier origin of dorsal (?) ; color pattern, especially absence of dark spots and presence of light patches; lesser size.

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Plate 1

Fig. 1.—*Clinus puellarum sp. nov.* Holotype. East Beach, Low Head, Tasmania. Standard length 52·0, total length 59·2 mm.

Fig. 2.—*Syngnathus mollisoni sp. nov.* Holotype. Off Bivouac Bay, Tasman Peninsula, Tasmania. Standard length 159·2, total length, 162·8 mm.

Tasmanian Garden Escapes

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Under comparatively mild conditions and with a well distributed rainfall, it is not surprising to find many garden plants, particularly those of British origin, that have found conditions well-suited to their development and increase in Tasmania.

In order to simplify this discussion the following definitions may be of assistance:—

(1) a " garden plant ", in its most general sense, is a flower, fruit, vegetable, herb or ornamental normally cultivated in Tasmanian gardens for house use or ornamental purposes.

(2) a " garden escape ", then, is a garden plant as defined which has found local conditions so favourable that it has spread beyond the bounds of the original cultivated or enclosed area and proved its ability to compete successfully with native and other flora.

However, it is often difficult to be precise. For example, Poppies, Blue Echium, Chamomile and even Horehound and Scotch Heather may have been introduced and used as garden plants here, but are regarded as wild flowers in Great Britain. Again they might have come in pasture or grain seeds, an origin which could be presumed to exclude them from the category of a " garden escape ". Another query in regard to the use of the term " escape " is the matter of degree—how often and how effectively must a plant escape to place it in the true escape class, and where can the line be drawn? Most of the plants listed could be classed as frequent and definite.

Bearing in mind these considerations, the list which follows, though open to considerable criticism, endeavours to cover the field as it appears at the present time. Most of the " common names " given are of English origin but variations in usage often occur. So far as the Botanical names are concerned a number of specimens may require further checking in regard to species. Under the heading " Observations " reference is first made to frequency and distribution, then the situation or local conditions

which it apparently favours, and finally one or two of the districts or locations where the plant has been seen.

Common Name	Botanical Name	Family	Observations
Alyssum	*Lobularia maritima* (L.) Desv.	Cruciferae	Road cuttings, rocky banks, e.g., Austins Ferry, &c.
Convolvulus	*Calystegia sepium* (L.) Roem. et Schult.	Convolvulaceae	Scattered, e.g., suburban
Daisy Bush (yellow)	*Eutyops abrotanifolius* D.C.	Compositae	Scattered and frequent Channel areas
Daisy (rock)	*Felicia erigeroides* D.C.	Compositae	Scattered, suburban
Eschscholtzia	*E. californica* Cham.	Papaveraceae	Occasional on good soils, Kingston
Forget-me-not	*Myosotis sylvatica* Ehrh.	Boragineae	Scattered and frequent: creek beds, &c., N.W. and Fingal
—	*Myosotis arvensis* (L.) Hill	Boragineae	Roadsides, Eaglehawk Neck
—	*Myosotis palustris* L.	Boragineae	Roadsides, National Park
Foxglove	*Digitalis purpurea* L.	Scrophulariaceae	Scattered and frequent, Pyengana, Wyena, &c.
Honesty	*Lunaria annua* L. (Syn. Lunaria biennis Moench)	Cruciferae	Occasional, roadsides, Kingston and suburban
Lupin	*Lupinus arboreus* L.	Leguminosae	Scattered and extensive: Seven Mile Beach, Bridport
Linaria	*L. bipartita* Wild	Scrophulariaceae	Occasional, sands, coastal and suburban
Marigold (Pot.)	*Calendula officinalis* L.	Compositae	Scattered, suburban
Musk	*Mimulus moschatus* Doug.	Scrophulariaceae	Scattered, ditches, Nat. Park, Lilydale
Mullein	*Verbascum thapsus* L.	Scrophulariaceae	Scattered and extensive, Sorell, &c.
—	*Verbascum virgatum* Stokes	Scrophulariaceae	Frequent, roadsides, Bushy Park
Mignonette (Dyer's Rocket)	*Reseda luteola* L.	Resedaceae	Scattered and extensive: Sorell, Sandfly, &c.
Oxalis (pink)	*O. latifolia* H.B. et K.	Geraniaceae	Scattered and extensive: suburban
Oxalis (Soursob) (large yellow)	*O. cernua* Thunb.	Geraniaceae	Scattered, suburban
Blue Echium (Patersons Curse)	*E. plantagineum* L.	Boraginaceae	Scattered, North East and Tamar
Blue Echium (Vipers Bugloss)	*E. vulgare* L.	Boraginaceae	Scattered, North East and Tamar
Poppy	*Papaver somniferum* L.	Papaveraceae	Scattered, general, e.g., Sassafras and North West
Scabious	*S. atropurpurea* L.	Dipsacaceae	Scattered, roadsides and suburban
Valerian (spur)	*Centranthus ruber* (L.) D.C.	Valerianaceae	Scattered, extensive, general, banks and cuttings, Kingston, suburban
Winter Heliotrope	*Petasites fragrans* (Vill.) C. Presl.	Compositae	Scattered and suburban

SHRUBS

Common Name	Botanical Name	Family	Observations
Broom (Canary)	*Cytisus monopessulanus* L.	Leguminosae	General and extensive, Kingston, Scottsdale, &c.
Broom (Common)	*Cytisus scoparius* Link	Leguminosae	General and extensive, Kingston, Scottsdale, &c.
Hypericum (Rose of Sharon)	*H. calycinum* L.	Guttiferae	General roadsides, Bruny Is., North and North West
Hypericum (Tutsan) L.	*H. androsemum*	Guttiferae	General roadsides, Bruny Is., North and North West
Fuchsia	*F. magellanica* Lam.	Onagraceae	Occasional, e.g., Oyster Cove, West Coast and Coastal
Heath	*Erica lusitanica* Rud.	Ericaceae	General and extensive, Huon, Lilydale, &c.
Heather (Scotch)	*Calluna vulgaris* (L.) Hull	Ericaceae	Occasional on acid sands Kingston, Bruny Is.
Periwinkle	*Vinca major* L.	Apocynaceae	Scattered and general, roadsides, Cressy West Tamar
Tree Lucerne	*Cytisus proliferus* L.	Leguminosae	Scattered, roads, suburban
Four other shrubs might qualify in this section—			
Barberry	*Berberis vulgaris* L.	Berberidaceae	Frequent southern districts, Sorell
Hawthorn	*Crataegus monogyna* Jacq.	Rosaceae	General, e.g., Cressy and Lake River
Laurel	*Laurus nobilis* L.	Lauraceae	Occasional, e.g., Tamar
Sweet Briar	*Rosa rubiginosa* L.	Rosaceae	General and extensive, Brighton, Conara
African Boxthorn	*Lycium ferocissimum* Miers	Solanaceae	Originally planted as shelter hedges and ornamental in exposed situations, has also spread, particularly in the central districts, Tunbridge, &c.

BULBS AND CORMS

The following plants, though multiplying in most instances mainly by bulbs or corms, have succeeded doubtless mainly by mechanical distribution, in establishing themselves firmly in many localities.

Common Name	Botanical Name	Family	Observations
Daffodil	*Narcissus Pseudo-Narcissus* L.	Amaryllidaceae	Frequent and general fields and ditches, Channel, Tamar
Ixia	*I. maculata* L.	Iridaceae	Scattered, mainly suburban, Taroona
Watsonia	*W. meriana* Mill var. iridifolia Ker-Gawl.	Iridaceae	Scattered, Huon, Gordon, Mt. Direction, East Tamar

FRUITS

Common Name	Botanical Name	Family	Observations
Blackberry	*Rubus* spp.	Rosaceae	General and extensive, hedges and waterways
Cherry (Kentish)	*Prunus cerasus* L.	Rosaceae	Scattered and amongst hedges, &c., Huon and foothills, East Coast
Cherry Plums	*Prunus cerasifera* Ehrh.	Rosaceae	Scattered and amongst hedges, &c., Huon and foothills, East Coast
Plums	*Prunus domestica* L.	Rosaceae	Scattered and amongst hedges, &c., Huon and foothills, East Coast
Apple (seedling)	*Pyrus malus*	Rosaceae	Scattered, hedgerows, &c., Scottsdale, Channel, Huon
VEGETABLES AND HERBS			
Chicory	*Cichorium intybus* L.	Compositae	Scattered, roadways and embankments, e.g., Claremont
Chamomile	*Anthemis nobilis* L.	Compositae	Scattered, mainly suburban
Salsify	*Tragopogon porrifolius* L.	Compositae	Scattered, mainly suburban
Water Cress	*Nasturtium officinale* R.Br.	Cruciferae	Scattered and general, creek beds, e.g., Bridgenorth
Mint	*Mentha piperita* L.	Labiateae	Scattered and general, ditches, Sheffield
TREES			
Elm (corky bark)	*Ulmus thomasi* Sarg.	Ulmaceae	Scattered, Kingston, Perth, &c.
Pine	*Pinus radiata* Don.	Coniferae	Scattered and general, Longley, Tunnel Hill
Willow (weeping)	*Salix babylonica* L.	Salicineae	Scattered and general, rivers and waterways
Willow (white × crack)	*S. alba* × *fragilis*	Salicineae	Scattered and general rivers and waterways.

The following trees have been noticed occasionally, mostly as isolated trees or groups of two or three—

Ash	*Fraxinus excelsior* L.	Oleaceae	Scattered and suburban
Sycamore	*Acer pseudoplatanus* L.	Sapindaceae	Scattered and suburban
Birch	*Betula alba* L.	Cupuliferae	Scattered and suburban

ACKNOWLEDGMENTS

It is desired to acknowledge the assistance of Dr. W. M. Curtis, University of Tasmania, in checking the list detailed; to Mr. H. A. Turner late of the Tasmanian Department of Agriculture and Dr. D. Martin for helpful information regarding Northern districts, and others from whom specimens and information have been received from time to time.

REFERENCES

Identification and nomenclature has been based on the following works:—

"Flora of the British Isles" Clapham, Tutin, and Warburg.
"Manual of Cultivated Plants" L. H. Bailey.
"Wayside and Woodland Blossoms" Edward Step.

Papers and Proceedings of the Royal Society of Tasmania, Volume 89

A Note on *Ghost Moths*—family HEPIALIDAE

Abantiades hyalinatus (Herrick Schaeffer)

By

J. R. Cunningham

Tasmanian Museum, Hobart, Tasmania

Little seems to be known of the life history of this beautiful moth. The writer has carried out some observations in the Kingston (Tasmania) Area where the peppermint gum (*Eucalyptus amygdalina*) seems to be the tree most favoured by this insect. The perfect insects emerge after heavy rain about the middle of January or February.

The eggs dropped as the large female flutters over the eucalypts are at first cream coloured, but change to a dark leaden colour in a short time. The exact time lapse from egg to emergence of adult is not known but there appears to be an emergence each year. Full grown larvae and pupae have been collected in December in silk lined tunnels leading to the roots of the gums on which they feed.

When the larva is ready to pupate, the hole is sealed with a lid of earth and silk about an inch below the surface of the ground. This lid is pushed out by the pupa when it works its way up the tunnel, by the ridges on the abdominal segments.

Full grown larvae have been observed creamy white in colour and averaging 107 mm. in length. Observations on the pupae show them to be castaneus brown, about 82 mm. long and 17 mm. in diameter.

The females vary little except in size but three colour forms in the male have been noted at Kingston. These are forms *brunneus, imperialus* and a *brunneus* form of *erythrinus* which does not seem to have been recorded before. The true *hyalinatus* male with ochreous wings is common in this area.

The *erythrinus* without silvery-white markings in the forewings, was caught in cop with a large female hanging to a small tree. Both specimens are in the Tasmanian Museum Collection.

Papers and Proceedings of the Royal Society of Tasmania, Volume 89

The Tertiary Volcanic Rocks of Lower Sandy Bay, Hobart

By

Alan Spry

Department of Geology, University of Tasmania

(with 3 plates and 6 text figures)

Abstract

Alkali-basalt (nepheline basanite) and basic pyroclastics occur near Blinking Billy Point where they overly Tertiary lacustrine beds. The latter consist of a boulder bed, probably of landslide origin, and mudstones which contain poor plant fossils. There is a total thickness of at least 450′ of Tertiary rocks lying on a down-faulted block surrounded by Permian and Triassic sediments and Jurassic Dolerite. The Tertiary rocks were folded against the confining blocks by forces associated with the rise of magma during vulcanism.

Introduction

The area described here, and shown in fig. 1 is located at Blinking Billy Point (formerly One Tree Point), Sandy Bay, about three miles south of Hobart. The Tertiary rocks are limited to an area of about fifty acres and are only exposed to any extent in the cliffs or in excavations and road cuttings.

The sequence appears to be as follows:

Volcanic Rocks	Dolerite Boulder bed	5′	+
	Blinking Billy Point basanite	80′	(?)
	Tuff	1–5′	
	Basanite	0–15′	
	Interbedded basanites and pyroclastics	250′	
Lacustrine Sediments	Mudstone with plant remains	20′	
	Boulder Bed	60′	+

Previous Literature

Ease of access has led to the investigation of this area by a number of workers in the past. The discovery of " basaltic lava " and " brecciated scoria " on the " west side of Storm Bay " by Darwin (1844) was probably the first reference to this locality. Johnson (1881) was the first to give a detailed description of the lacustrine and volcanic rocks together with the fossils present. He briefly outlined the structure of the area and related the rocks to those at Cornelian Bay and Lindisfarne. A brief reference was made to marsupial bone fragments found apparently in a joint in the basanite. He regarded the boulder bed as the result of landslides from steep cliffs.

White and Macleod (1898) gave a description and chemical analysis of the Blinking Billy Point basanite. Petterd (1910) recorded melilite and hauyne in the same rock. Noetling (1913) gave further details of the area, particularly of the structure in the large cutting on Sandy Bay Road. He suggested that the boulder bed and "leaf bed" were shoreline sediments which had been deposited on a downfaulted block. He considered that the boulder bed was a Pleistocene till and that the vulcanism was consequently post-Pleistocene. Aurousseau (1926) presented a valuable and detailed description of the basanite together with a chemical analysis. He discredited the analysis of White and Macleod (1898) and showed that the determination of fayalite by White and Macleod (1898) and of melilite and hauyne by Petterd (1910) were incorrect. He classified the lava at Blinking Billy Point as a nepheline basanite and discussed the origin of the iddingsite. Edwards (1949) grouped the basanite with similar rocks from other Tasmanian localities in a regional petrological study. An account of the regional geology of the surrounding area by Carey and Banks has not yet been published.

Tertiary Rocks

Lacustrine Sediments

Probably the oldest representative of the Tertiary System in the area is the boulder bed which is exposed in the central and northern parts of the large road cutting at Blinking Billy Point. It consists of large angular fragments of Permian sediments set in a light coloured, fine grained matrix, and is very poorly sorted with no bedding visible. The large fragments are generally not more than a foot across although boulders up to four feet in diameter are found. Similar boulder beds have been found close to this fault system from Taroona to Claremont by S. Warren Carey (personal communication) who first realised their tectonic significance. A mechanical analysis shows that the sediment lacks sorting and is bimodal in character with the boulder and the silt-clay fractions predominating. Pebbles and sand are present but to a lesser extent. A detailed analysis is not given because of the difficulty in sampling a bed containing such large boulders. This rock is called a *boulder* bed rather than a *breccia* because the unsorted nature prevents any exact terminology. The clastic fragments present show a complete range of sizes from clay to boulders and there is less than 50 per cent in any one size class.

The fragments of greater than sand size are of Permian mudstone and are very angular with a moderate sphericity. The smaller fragments consist of quartz and Permian mudstone with a high degree of angularity and low sphericity. The angularity increases with the size of the particle. The shape of the fragments suggests that the smaller ones were formed by the smashing together of the larger fragments during transportation.

The texture is typical of till, landslide debris or mudflow material. The boulders show a random distribution in the lower parts of the bed but a tendency for them to be concentrated in layers becomes marked towards the top.

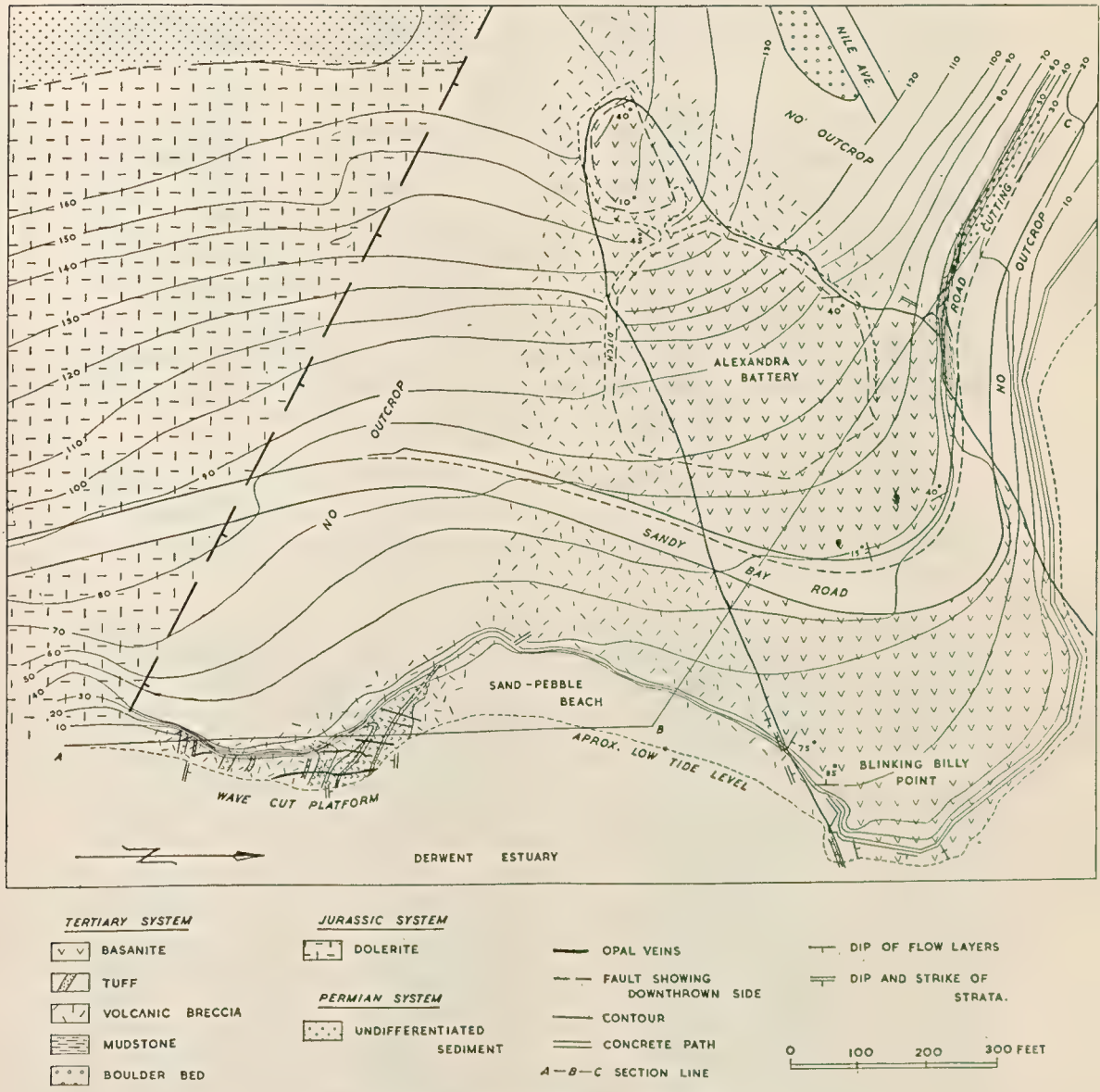

FIG. 1.—Map of the Blinking Billy Point area.

The base of this formation is not exposed due to subsequent road construction, but as Johnson (1851) stated that it then extended down to sea level, there would be a thickness of at least 60′ present.

The overlying bed is a white mudstone which differs from the boulder bed only in that it lacks large boulders, possesses well developed bedding and contains plant fossils. Boulders are distributed rather sporadically

throughout, and many are concentrated in distinct layers. Some layers are rich in pebbles or in coarse sand. The upper part of the mudstone contains poorly preserved leaves, twigs and fruit as described by Johnson (1881).

A mechanical analysis shows that the mudstone is poorly sorted and closely resembles the matrix of the boulder bed. It is composed predominantly of clay but with about 10 per cent of sand and 40 per cent of silt. The fragments are angular with a moderate sphericity but show a somewhat higher degree of roundness and sphericity than the boulder bed matrix. This would be due to some attrition during transport by running water although the large proportion of small rock fragments and the lack of sorting indicates that the sediment is not a normal mudstone. It probably resulted from the rapid erosion of debris on the steep fault scarps, with only slight washing on the lake floor.

In the centre of the syncline in the main road cutting is a few feet of post-volcanic boulder bed which is composed chiefly of rounded dolerite boulders in a clay matrix. This is also well exposed along Nile Avenue.

Following the work of Carey (1946, 1954) it is believed that early in the Tertiary, major faulting took place along the present location of the Derwent which was then an irregular, complex graben. Lakes were formed on the downthrown blocks and considerable thicknessess of clays and sands accumulated. The boulder beds are located close to the fault scarp margin of the lake and are composed of debris shaken off the scarp during earthquakes caused by later movements along the faults. The massive beds towards the base of the main road cutting may partly consist of mudflow debris which flowed off the steep slopes after heavy rains following earthquakes and uplift. As the lower boulder bed is rich in Permian mudstone boulders while the upper boulder bed contains chiefly Jurassic dolerite boulders, it appears that erosion removed the mudstone which composed the scarp before the vulcanism to expose an underlying dolerite sill which was the source of the post-volcanic debris. The difference in angularity between the mudstone and the dolerite boulders is probably attributable to differing modes of weathering of these rocks rather than to differing processes of transportation or differing amounts of corrosion. The jointing in the mudstone caused it to form angular blocks while spheriodal weathering of the dolerite resulted in round boulders. This latter tendency would be accentuated if the climate was warmer and more humid as suggested by the flora present.

The white mudstone was deposited during the period of comparative quiescence which followed the faulting. Each layer of pebbles or boulders represents a sudden earthquake with uplift due to repeated movements along the faults indicating that normal deposition was periodically interrupted.

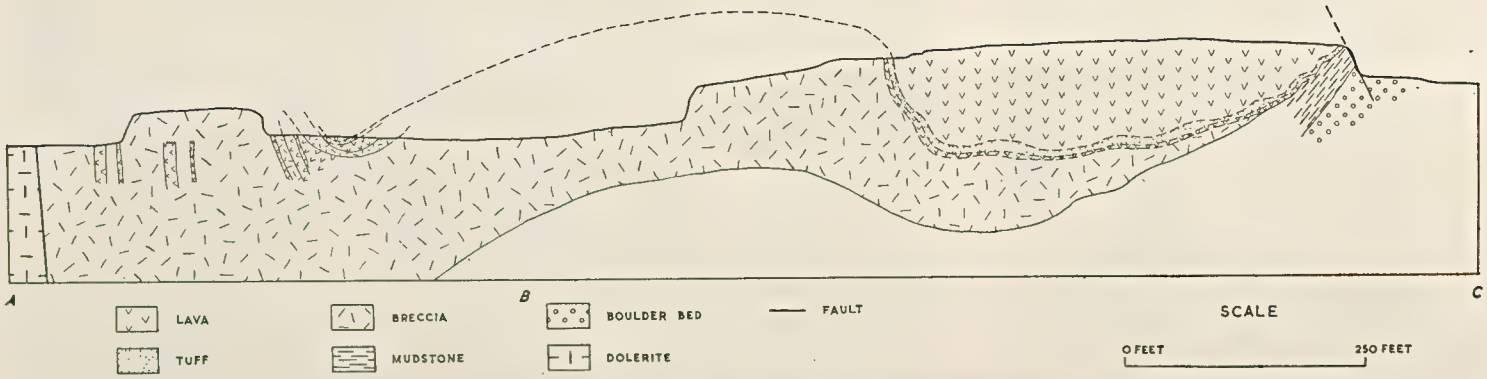

FIG. 2.—Section across fig. 1 from the main road cutting C, to the wave-cut platform A.

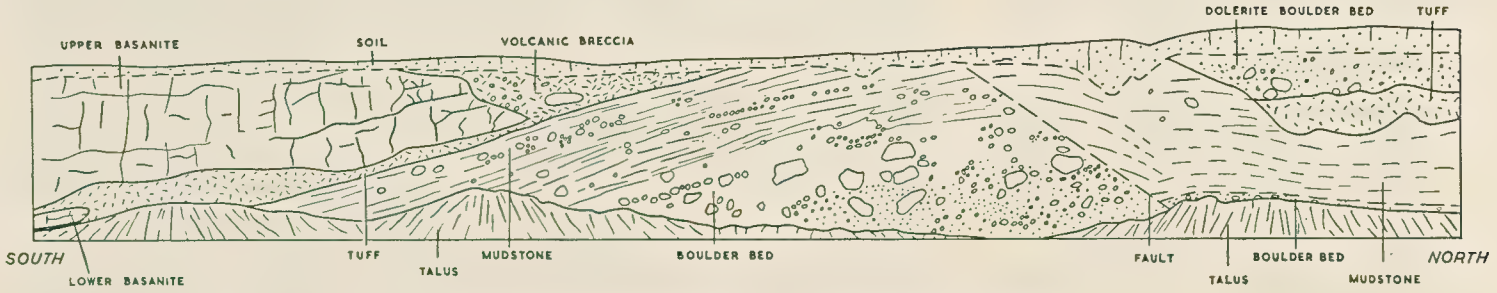

FIG. 3.—Section along portion of the Sandy Bay Road cutting.

Volcanic Rocks

The sequence from top to bottom is as follows:

Wave-cut Platform		*Main Road Cutting*	
basanite	10′ +	Blinking Billy Point basanite	80′ (?)
red tuff	3′ — 5′	tuff	1 — 4′
basanite	0 — 15′	basanite 2′ (perhaps thicker in part)	
breccia with thin lava flows	250′ (?)		

The oldest volcanic rocks in this area are exposed on the wave-cut platform on the small promontory just south of Blinking Billy Point. There is at least 250′ of interbedded lavas and pyroclastics which are quite strongly folded as shown in figs. 4, 5 and 6.

In the small bay in the centre of the area is a volcanic breccia which may be 60′ thick; this is the equivalent of the lower breccias and tuffs of the wave-cut platform.

Lavas

The lavas are dark grey, fine grained and speckled with flecks of red iddingsite, and show only a slight variation in composition between different specimens. The Blinking Billy Point basanite is generally massive except for a platy flow structure which is strongly developed in some parts (see plate 1 No. 1), while some of the thinner flows are quite scoriaceous and ropy. One thin flow, now vertical, on the southern end of the wave-cut platform shows a fine-grained base and scoriaceous top as shown in plate II, No. 1. The base of the Blinking Billy Point basanite and that of the probably equivalent lava above the red tuff on the wave-cut platform, are rich in small sedimentary xenoliths. These show only slight metamorphic effects, being baked and slightly silicified with chalcedony. A thin section shows that there is a distinct concentration of feldspar around some xenoliths.

The lavas grade from massive to blocky varieties and some pass abruptly into breccia along the strike. This is seen at the top of the main road cutting at its southern end in fig. 3.

Thin sections show the lavas to be very fine grained, holocrystalline and porphyritic. They consist of euhedral to subhedral phenocrysts of iddingsite (after olivine) in a fine groundmass composed of pyroyene, nepheline, feldspar, iron ore and apatite. Secondary opal and chalcedony fill tiny amygdales.

The iddingsite averages 0·2 mm. diameter but may be as much as 1 mm. across and is usually deep red with a peripheral zone which is darker in colour and rich in iron ore inclusions, see plate 3, No. 1. It is weakly pleochroic, biaxial negative with an optic axial angle about 45°, and has straight extinction on the single, well-developed cleavage. Many cyrstals contain inclusions of apatite, while others are surrounded by a growth of pyroxene. The iddingsite has replaced olivine due to a late magmatic (?) reaction involving addition of water and silica.

The pyroxene occurs as abundant, tiny prisms which are usually only ·02 mm. across but which are up to ·2 mm. in some specimens. It is faintly pleochroic from light yellowish green to light green. Some crystals are

twinned and others show hourglass structure. The flow structure of the basanites is shown by parallelism of these prisms.

Apatite is a fairly abundant accessory and it shows unusual properties. It occurs as pale purplish grey prisms which are faintly pleochroic with a very low birefringence. The well formed crystals are usually about ·04 mm. diameter and up to ·3 mm. long and thus occur as distinct phenocrysts. It contains many tiny inclusions in the order of ·0005 mm. across, which are ilmenite or possibly rutile. These occur as needles parallel to the C axis or as plates oriental parallel to the hexagonal prism face of the apatite.

TABLE I

Nepheline basanite, Blinking Billy Point

			Norm
SiO_2	45·59		
Al_2O_3	12·48	or.	18·62
Fe_2O_3	9·93	ab.	21·48
FeO	2·84	an.	0·83
MgO	4·71	ne.	12·50
CaO	8·26	hl.	0·23
Na_2O	5·51	th.	0·10
K_2O	3·16	di.	22·68
H_2O+	1·73	ol.	1·68
$H_2O—$	1·64	mt.	3·71
CO_2	Nil	il.	3·93
TiO_2	2·10	hm.	7·36
P_2O_5	1·65	ap.	3·86
MnO	0·16	H_2O	3·37
Cl	0·16		
SO_3	0·09		100·35
	100·06		

Analysis by Aurousseau (1926).

The dark minerals are set in a clear, colourless, almost isotropic material of low refractive index, which the analysis (table 1) by Aurousseau (1926) indicates to be a mixture of nepheline, orthoclase and plagioclase. The quotation of this analysis by Edwards (1948) is incorrect in the amount of SiO_2, has H_2O+ and $H_2O—$ transposed, and omits SO_3. Nepheline is recognizable as tiny hexagonal prisms showing zonal structure but the feldspars are rarely distinguishable. There may be more nepheline than the 12·5 per cent indicated in the norm in Table I, because free silica (of secondary origin) is present in the rock and some of the 40·93 per cent of normative feldspar may actually be present as nepheline, feldspar, and chalcedony or opal. Despite Aurousseau's (1933) doubt of the validity of Petterd's (1910) hauyne, there is a small amount of a mineral present which might actually be hauyne, thus explaining the ·09 per cent of SO_3 in the chemical analysis. Gypsum, sulphur, mirabilite and thenardite were reported by Aurousseau (1933) although these were not observed by the author.

There is usually about 5 per cent of free silica present as concentric layers of opal and chalcedony in tiny amygdales and these are probably the " sulphate vesicles " referred to by Aurousseau (1933). The silica is a post-magmatic introduction to a rock which clearly shows its undersaturated character by the presence of olivine and nepheline. The magma originally contained nearer 40 per cent silica rather than the 45·59 per cent shown in the analysis.

The most common composition is about 45 per cent of felsic minerals with 35 per cent augite, 7 per cent red iddingsite, 7 per cent iron ore, 4 per cent opal and chalcedony, and 2 per cent apatite as shown in specimens 6079, 6080, 6084, 6087, 6088, 6089, 6098 in the collection of the Department of Geology, University of Tasmania. Some rocks however differ from this general description give above in containing much more pyroxene (up to 55 per cent) and less feldspar and feldspathoid (about 25 per cent). These also contain iddingsite which is yellow. Specimens numbered 6078, 6090, 6091, 6092 belong to this group.

The basanite (6079*b*) above the red tuff on the wave-cut platform is very rich in augite and differs highly from the other lavas in containing pyroxene phenocrysts, together with clots of feldspathoid. One other lava here (6079*a*) is quite rich in green opal.

The common rock is an undersaturated, alkaline, olivine basalt and thus is classed as a basanite, and because of the abundance of nepheline, it would best be called a nepheline-basanite.

Breccia

The coarse pyroclastics are massive, unsorted breccias consisting of angular blocks of very scoriaceous lava. They possess no bedding and often very little matrix (see plate 2, No. 2). The fragments are usually about 6″ across but some large, well formed bombs are almost a yard long. Following the terminology of Wentworth and Williams (1932), the fragments appear to be all *essential* and *accessory* ejecta without any *accidental* material.

At the north end of the little cliff above the wave-cut platform a coarse breccia grades upwards into fine breccia which passes into a well-bedded, reddish lapilli-tuff containing bands of finer tuff. This transition also takes place laterally, a few yards further south along the cliff face.

Tuffs.

The fine grained pyroclastics are much less abundant than the breccias but are well shown in the following places:—

(*a*) Immediately below the Blinking Billy Point basanite in the road cutting is about 18″ of dark-brown, vitric tuff (6082). It is composed chiefly of small angular fragments of scoriaceous, brown glass. The tachylyte contains a little fresh olivine (?), iddingsite and much iron ore while the amygdales are usually filled with chalcedony.

(*b*) In the north-eastern end of the ditch around the old Alexandra Battery is a lithic-crystal tuff (6081). It is composed of angular fragments which are usually about 1 mm. in diameter but which range up to 5 mm. The fine grained basalt fragments present have been altered to a mixture of chlorite and brownish clay. Present abundantly are fresh augite crystals showing strong polysynthetic and herringbone twins (see plate III, No. 4). There are a few fragments of fresh basic plagioclase and a quartz-albite particle.

(*c*) On the northern end of the wave-cut platform is a bed of reddish tuff about 3′ thick. It is quite well bedded and thus differs from the other tuffs which are quite massive.

(*d*) At the southern end of the wave-cut platform is a coarse tuff with a distinctive red and white colour (6083). It consists of irregularly shaped fragments of amygdaloidal glass which is cemented by much calcite. A little clastic pyroxene is present, together with reddish brown opal. The amygdales of the lava fragments are filled chiefly with chalcedony. This tuff occurs immediately next to an opal vein which is very rich in calcite and thus the carbonate cement of the tuff can be attributed to a late hydrothermal introduction (see plate III, No. 3).

(*e*) At the western and upper extremity of the Blinking Billy Point basanite, in the ditch around the Alexandra Battery, there is a thin layer of tuff which lies below the basanite but above a massive volcanic breccia. It shows well developed prismatic jointing with tiny hexagonal columns only about 1 cm. across.

Hydrothermal Activity

Not only has there been considerable introduction of opal and chalcedony to the lavas as amygdale fillings but also those minerals, together with calcite, form distinct masses among the volcanic rocks of the wave-cut platform. A number of parallel, dyke-like veins up to 2½′ wide run approximately north-south as shown in fig. 5. These are composite veins composed of opal, chalcedony and quartz with variable amounts of calcite and are reddish, orange and white in colour with a crude brecciated and banded structure. These sections show that there was an introduction of red, almost opaque, opal first, and that this was followed and partially replaced by calcite giving a brecciated appearance to some specimens (6076). Later colourless, isotropic opal formed encrusting layers on the earlier minerals and this was covered by layers of birefringent, fibrous chalcedony and finally quartz giving a banded, crustified mass (6077) (see plate III, No. 2).

There is a line of outcrops of calcite-impregnated breccia running parallel to the opal veins on the wave-cut platform. A thin section (6093) shows that the scoriaceous basalt fragments are glassy with a little iron ore, pyroxene, apatite and iddingsite present as shown in plate III, No. 2. The amygdales are partly or wholly filled with carbonate with later opal and chalcedony which were deposited on the carbonate. Banded opal and chalcedony fill some amygdales.

There has been an introduction, chiefly of silica, filling some joints, and of calcite impregnating the porous breccia. Silica also entered the basanites and their xenoliths although to a lesser degree. It is presumed that these minerals were deposited from hydrothermal solutions during the late or decadent phases of volcanism. The opal and chalcedony in the lavas may have been deposited from late magmatic fluids derived from the magma of the flow although the magma is so basic that it is unlikely that it could yield a siliceous residue. Probably all the silica and carbonate

was deposited from fluids passing upwards from a deeper magma body to feed hot springs or geysers. The mineral sequence of calcite, opal, chalcedony and quartz appears to be typical of this area while silicification is found widely associated with Tertiary basalts throughout Tasmania.

Structure

The structure of the faulted Permian, Triassic and Jurassic rocks which surround the Tertiary complex is very difficult to determine because of the paucity of outcrop and the close settlement, consequently only a generalized interpretation is shown in fig. 6 which is based on Banks' unpublished work. The area has been broken up by Tertiary faults and the Tertiary rocks occupy a downfaulted block.

Figure 3 shows a section along part of the main road cutting on Sandy Bay Road. The boulder bed is overlain by mudstone, tuff and basanite. These generally strike at approximately 230°* and dip at 45° to the south west but towards the northern end of the cutting the beds form a broad anticline plunging shallowly to the west. The beds are disturbed in the central part of the cutting where a small syncline and a faulted anticline are visible. Six feet of tuff occurs in the centre of the syncline where it is overlain by several feet of dolerite-boulder bed. There has been a downthrow of approximately 18′ on the northern side of the normal fault which strikes at 135° and dips at 60° to the north-east. A number of tiny horizontal faults occur between the anticline and the syncline, and these show overthrusting of up to six inches from the north. A number of small faults with throws of an inch or so occur in the plant-bearing mudstones, sandstones and boulder beds in an excavation on the corner of Wayne Street and Sandy Bay Road, where they strike at 210° and dip at 45° to the east.

The Blinking Billy Point basanite has the form of a shallow assymetrical syncline which plunges at 10° into the Derwent, and this was first recognized by Carey (personal communication). The northern limb dips at 45° in the prominent exposure in the main road cutting but flattens a few feet to the south where the underlying tuff thickens rapidly and part of a thin lower flow appears, as shown in fig. 3. The flat dip is seen just above sea level on this limb of the fold, where the lower flow is at least 12′ thick and there is a breccia between the two lavas. The thin lower lava is also visible on the southern limb of the fold where it is separated from the main basanite by a foot or so of breccia. The flow structures within the basanite show strong irregularities as shown in fig. 1, thus indicating undulations within the main fold. These undulations are probably of primary origin due to lava flowing over an irregular layer of tuff.

The volcanic rocks exposed on the wave-cut platform of the small headland just south of Blinking Billy Point, show quite strong folding. The interbedded lavas, tuffs and breccias show dips up to 90° (see plate I, No. 2).

* All bearings are taken from true north.

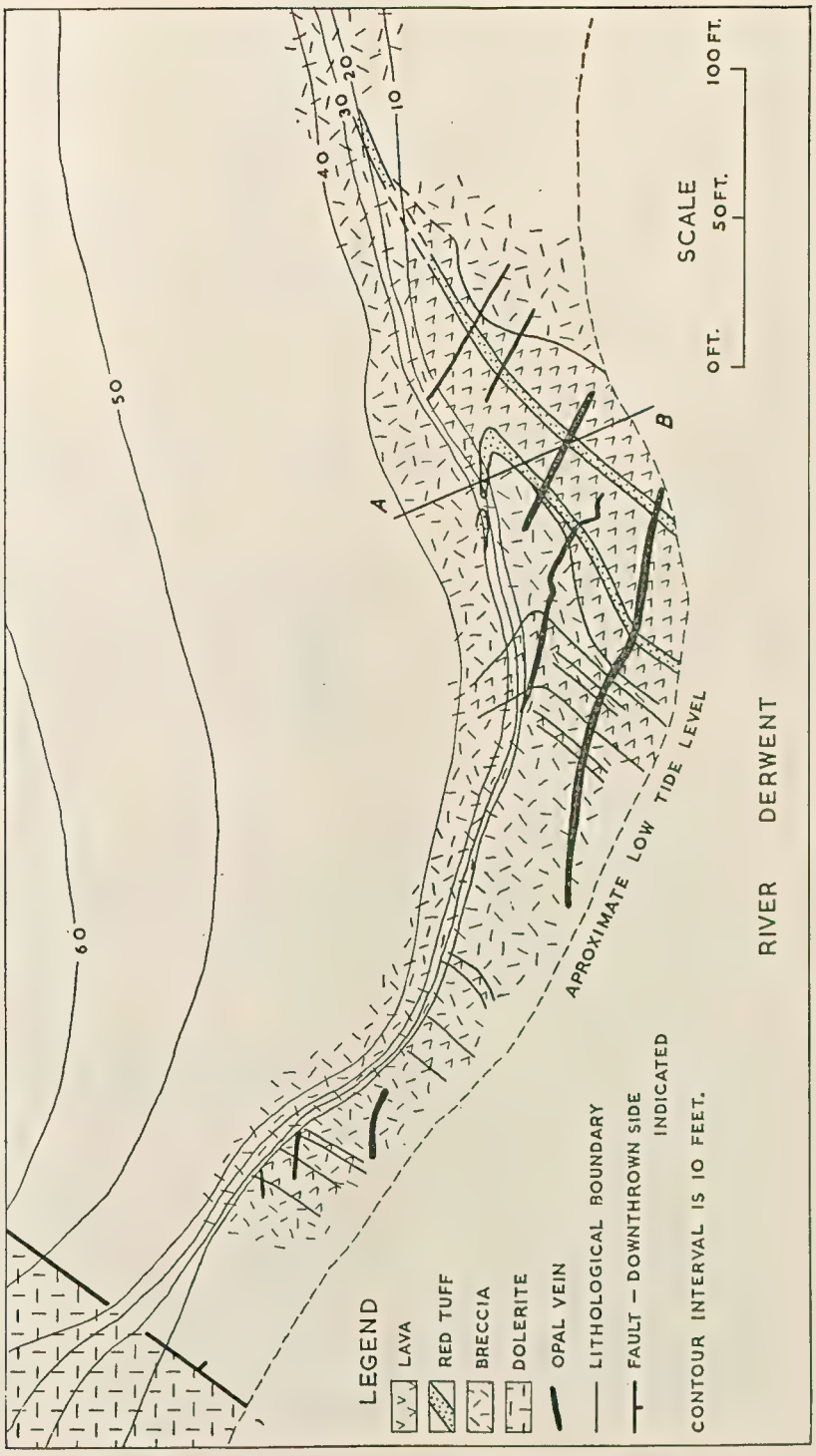

FIG. 4.—Detailed sketch of the wave-cut platform.

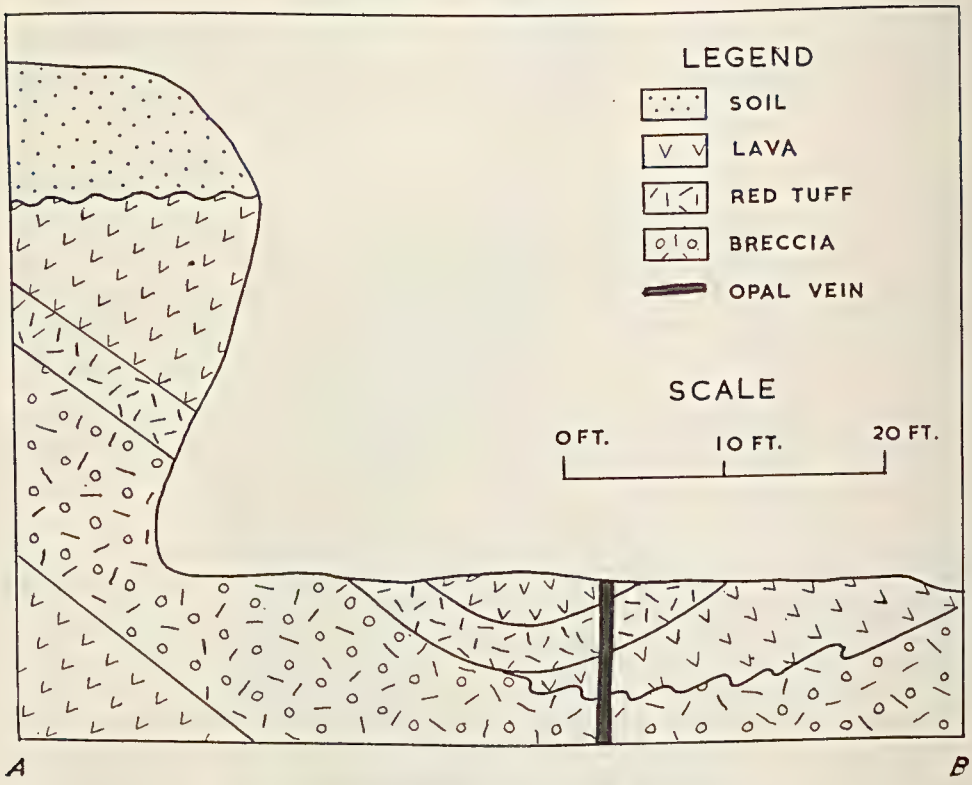

FIG. 5.—Section across the wave-cut platform.

A simple syncline is outlined by the red tuff on the northern end of the platform and this is illustrated in fig. 5. Immediately below the tuff on the north-eastern side of this fold is a scoriaceous lava, whereas on the south-western side there is about 15′ of coarse breccia between the lava and the tuff. It is a characteristic feature that all the volcanic rocks show quite rapid variations in thickness.

The structure of the rocks on the central and southern parts of the platform is difficult to determine. There is a change from the northerly dip of the southern flank of the syncline to a southerly dip and this is followed by vertical dipping beds containing one lava showing a distinct north-facing as shown in plate II, No. 1.

When one looks at the face of the cliff above the platform for confirmation of the folding, it is seen to consist of a uniform, unsorted mass of breccia lacking either bedding or interbedded lava flows. The general relations suggest that the breccia lies unconformably on the eroded surface of the lower folded lavas and pyroclastics. Towards the southern end of the wave-cut platform, the breccia in the cliff face passes directly down into the breccia shown in fig. 2, thus showing that there is probably no unconformity. The cliff breccia dips vertically and the thin lava flows do not appear in the cliff because of very rapid thinning out. Thus the southerly dipping beds in the central part of the platform are overturned.

Structural interpretation in such folded volcanic complexes is difficult for the following reasons:—

(*a*) The pyroclasts usually lack bedding thus preventing determinations of attitude.

(*b*) Initial dips of lavas and tuffs may be quite high near centres of erution.

(*c*) There are abrupt changes of thickness and facies (breccia to tuff, lava to breccia or tuff).

(*d*) It is not possible to distinguish between similar looking breccias or lavas which have different positions in the sequence.

The structure between the syncline of Blinking Billy Point and the folded rocks to the south is obscure because of insufficient outcrop. The red tuff, together with the overlying and underlying lava flows pass very abruptly into a massive breccia which dips to the west, in the centre of the little bay. The breccia dips more and more steeply towards the basanite to the north until it is nearly vertical at the contact. Thus there is an assymetrical anticline in this bay. Although it cannot be proved, it is likely that the Blinking Billy Point basanite is equivalent to the lava above the red tuff which in turn is equivalent to the tuff immediately below the basanite in the main road cutting. Thus the thin lava just below the Blinking Billy Point basanite would then be equivalent to the discontinuous lava below the red tuff on the wave-cut platform.

Figures 1 and 6 show that the general structure within the area occupied by Tertiary rocks consists of a series of anticlines and anticlines whose axial directions converge and which are generally assymetrical with the southern limb of the synclines steeper than the northern.

Tertiary sediments and volcanic rocks in Tasmania are usually quite flat-lying, and where appreciable dips are found they are usually due to initial dip or to drag against faults. The rocks in this area differ in showing quite strong folding although they lie upon unfolded Mesozoic and Palaeozoic rocks. Carey (1954) has shown that vulcanism was associated with a period of epeirogeny and crustal tension. In Tasmania, Tertiary folding is restricted to pyroclastics and lavas in the dissected areas in and around composite volcanoes, e.g., that described by Brill and Hale (1954) on north-western Tasman Peninsula. Two possible mechanisms which might produce these structures are briefly outlined but as it is considered that a number of these volcanic centres will need to be studied before the details are clear, details will be left for a future paper.

The folding may be related to local compression associated with the rise of magma and volcanic eruption. The thin, unconsolidated sediments and still hot lavas would be folded in a *dècollement* manner with the basal lacustrine clays acting as a lubricant as the beds slid over the rigid basement of Mesozoic and Permian rocks and were pushed against the enclosing fault blocks. The association of folding with volcanic rocks and the relation between the fold axes and marginal faults, implies the vulcanism produced the energy for folding and the fault blocks controlled the structure pattern.

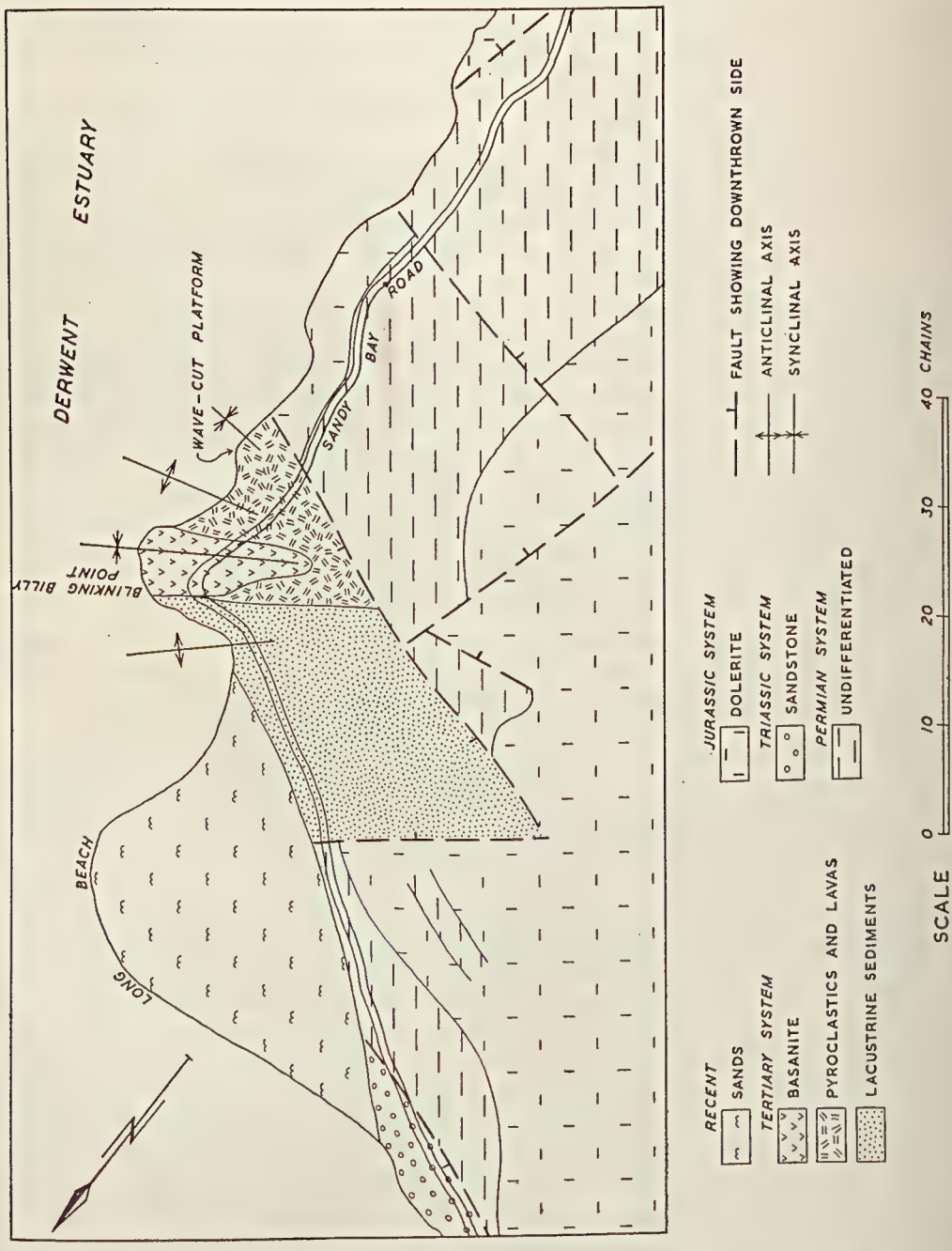

FIG. 6.—General structural environment of the volcanic rocks, chiefly after Banks.

It is possible that the folds were caused by a combination of the drag of the lavas passing over wet unconsolidated clays, together with gravity slumping down a slope. The cold lavas would be too brittle to fold without a considerable confining pressure, and as there is no evidence that the volcanics were covered by a large thickness of later materials then they must have folded when in a hot, plastic condition. This feature, combined with the assymetry of the folds suggest that the Blinking Billy Point basanite may have first flowed down a slope composed of lacustrine sediments and some volcanic rocks. When the lava was partly solidified, it slid down and crumpled the underlying material and was itself folded. The volcanic material as thicker towards the southern part of the area and the assymetry of the folds is in harmony with slumping towards the north.

Age of the Vulcanism

Johnson (1881) considered that the plant fossils indicated an Eocene age for the lacustrine beds while Noetling (1913) considered that they could be as young as Pleistocene. Lewis (1946) and Edwards (1949) considered that there were two separate periods of vulcanicity in Tasmania during the Tertiary and that these corresponded to the Older and Younger Basalts of Victoria. Lewis (1946) regarded the Blinking Billy Point rocks to be equivalent to the Younger Basalts.

Unfortunately the plant fossils are poorly preserved and in any case are not sufficiently diagnostic to give an age of better than Oligocene to Pliocene. Recent work throughout Tasmania, chiefly by Carey (personal communication), has not supported earlier ideas of more than one period of vulcanism in Tasmania during the Tertiary.

There is not sufficient data available to determine the age of the basalts although the following is known:—

(*a*) The basalts appear to be later than the Tertiary faulting.

(*b*) Basalt has been glaciated during the Pleistocene near the Great Lake.

(*c*) Basalt lies above Tertiary lacustrine beds which are approximately Miocene in age, in many places in Tasmania.

(*d*) Basalt lies on the eroded surface of Tertiary marine beds at Table Cape and Marrawah and these have been dated as Miocene (Gill and Banks, in press).

(*e*) The basalts show very deep dissection in many places throughout Tasmania and a study of the volcanic rocks of Sandy Bay illustrates this. Erosion has penetrated through the overlying basalt sheets to reveal the deep cores of the central volcanoes. The original volcanic cones have been either completely obliterated or persist as solid cores as at Table Cape. At Sandy Bay (also Tasman Peninsular, Cambridge and elsewhere) folded lavas have been truncated. As the degree of dissection resembles that of the Older Basalts of Victoria (Oligocene), rather than that of the Newer basalts (Pliocene), a tentative age of Miocene is advanced for the Tasmanian basalts. This is supported by the fact that Edwards (1949) showed that the Tasmanian basalts show petrological affinities with both the pre-Miocene and post-Miocene volcanic rocks of Victoria.

Summary and Conclusions

During the early Tertiary epeirogeny, the Derwent Valley was initiated as a graben bounded by a complex system of intersecting faults. Lakes formed on the downthrown blocks and a hundred feet or so of sediments were deposited at Sandy Bay. Further tension resulted in repeated movements along some faults and the rise of magma along major fractures. The initial vulcanism was of Icelandic type with numbers of central volcanoes situated along faults, and explosive eruption caused the deposition of lithic, vitric and crystal tuffs with basaltic breccias and thin lava flows. There were a number of large cones situated within the present Derwent estuary but these have been entirely removed by erosion. A cone existed a short distance south-east of Blinking Billy Point, just seawards of the wave-cut platform.

There has been continued erosion since this time and this has destroyed the cones which were located along the main valley line, and the remains were covered by water following the drowning of the estuary since the Pleistocene.

Acknowledgments

The author wishes to acknowledge the assistance of Professor S. Warren Carey whose interest in the area caused the work to be undertaken. Discussion of the problem with him has meant that many of his ideas have been incorporated in this work and although some have been acknowledged in the text, there are others which have become modified and have lost their original identity.

Thanks must go to M. R. Banks for allowing the incorporation of fig. 3 which is based on his unpublished map of the area. A. T. Wells and K. Nicholls assisted in the field mapping.

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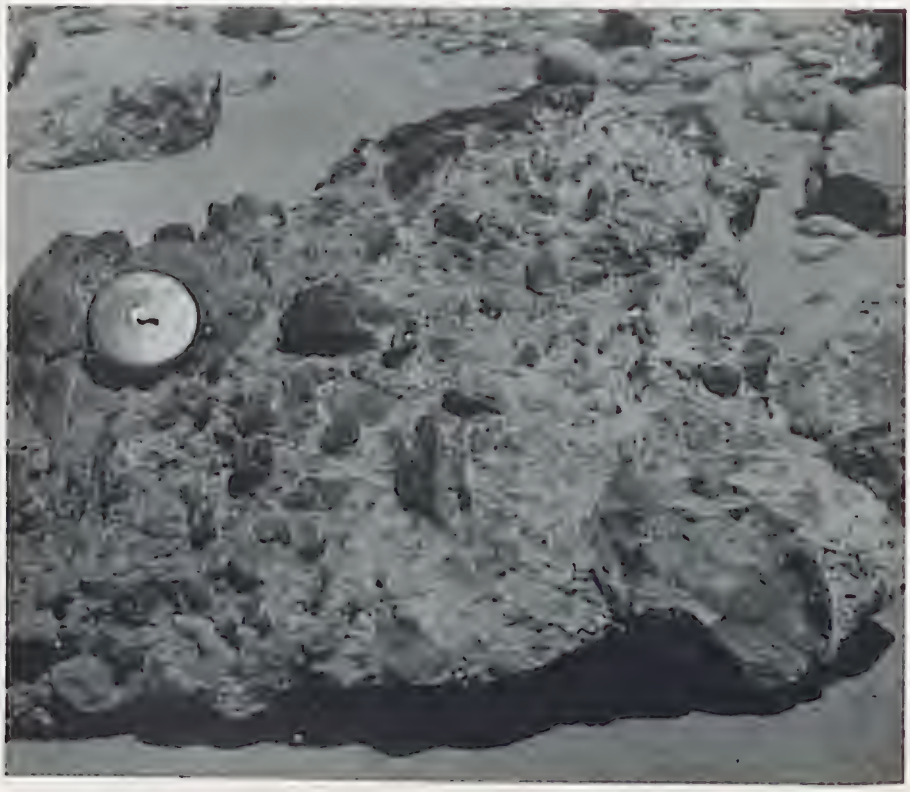
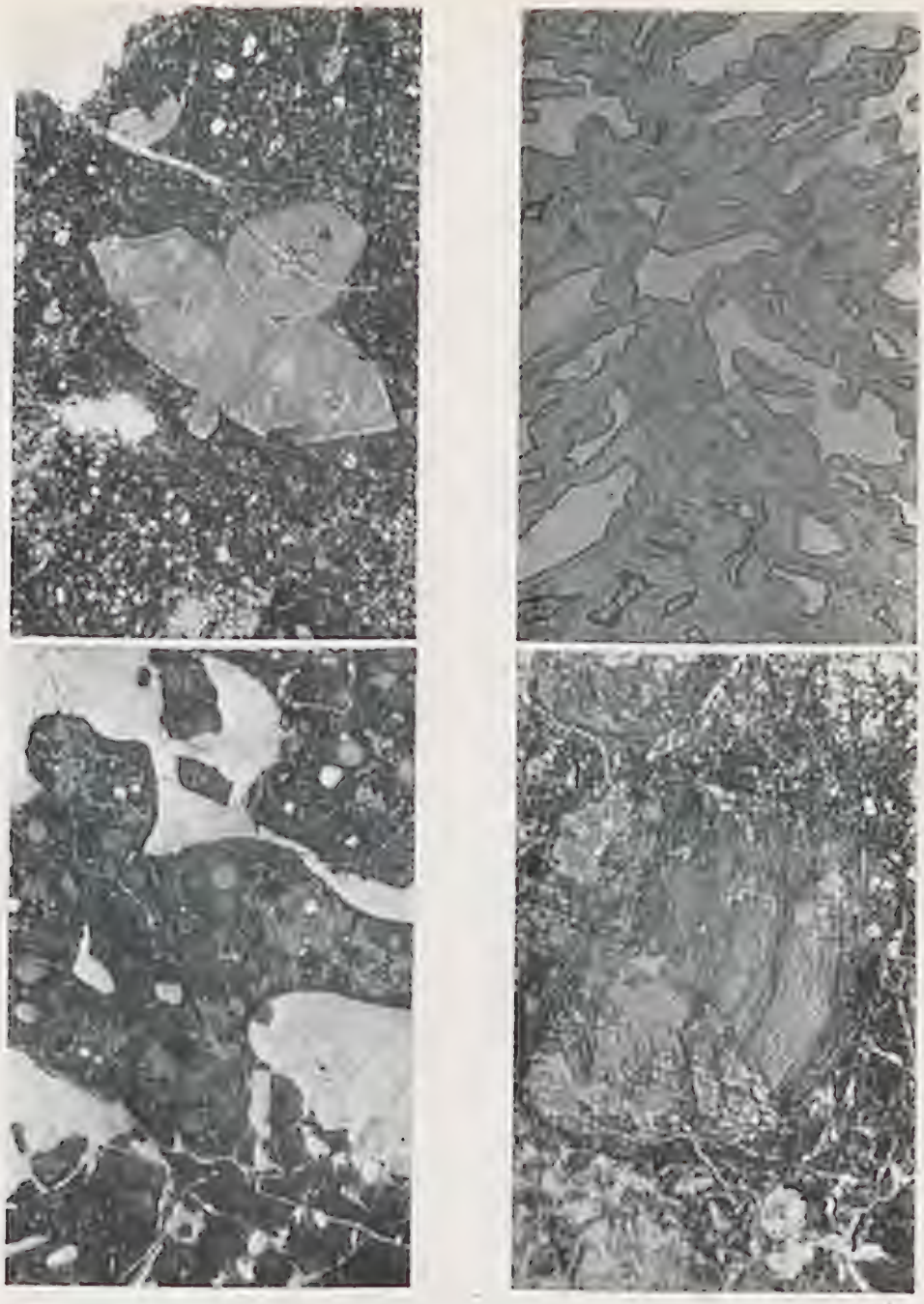
No. 1.—Vertical lava flow 18 inches thick showing fine grained base on left and scoriaceous "flow top" on right. Southern end of wave-cut platform.



No. 2.—Coarse volcanic breccia from cliff above wave-cut platform.



No. 1.—Photomicrographs of basanite showing iddingsite pseudomorphs after olivine. Ordinary light, magnification 70X. Slide 6078.

No. 2.—Photomicrograph of opal vein showing opal (darker) with crustification structure and chalcedony (lighter) in spaces. Ordinary light, magnification 40X. Slide 6077.

No. 3.—Photomicrograph of volcanic breccia showing dark-coloured glass fragments containing silica-filled amygdales, cemented by colourless calcite. Ordinary light, magnification 40X. Slide 6083.

No. 4.—Photomicrograph of pyroxene fragments in tuff. Crystal shows herringbone twinning. Ordinary light, magnification 40X. Slide 6081.

Geology of Portion of the Middle Derwent Area

By

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(with 5 plates and 1 text figure)

Abstract

A geological map is presented of an area of some 160 square miles lying between the Middle Derwent and Gordon Rivers. Ordovician limestone about 5000 feet thick followed by about 4000 feet of Silurian and Devonian sandstones and shales are folded into a major syncline. These rocks are overlain by less than 1000 feet of Permian sandstones, mudstones and glacial beds and more than 1000 feet of Triassic, freshwater sandstones and shales. The Permo-Triassic rocks are intruded by thick sills and transgressive bodies of dolerite in which large blocks several square miles in area are isolated. Prolonged peneplanation was followed in the early Tertiary by intense epeirogenic faulting forming horsts and graben, the latter being rapidly filled by lake sediments and extensive basalt flows.

Introduction

The area described is located along the Derwent River from near its junction with the Nive River south-eastwards to just beyond its junction with the Broad River. It extends to the west as far as the Gordon River and includes a large part of the Florentine Valley and portion of the Rasselas Valley. The maps extend about 4 miles east of the Derwent in map square 4577. The total area is approximately 160 square miles. Most of this is heavily vegetated with a range from Notofagus rain forest (up to 70 inches of rain per annum) and eucalypt forest, to savannah woodland and some button grass plain. The heavy vegetation conceals outcrops and greatly impedes movement.

Most of the field work has been carried out by tracing geological boundaries on the ground and transferring these on to aerial photographs. Locally, chain and compass traverses were used, and in the area north-east of the Derwent on map square 4477, a number of existing stadia traverses were used as a control. The Eldon Group rocks which comprise the Gordon Range were mapped largely by photo-geological interpretation, in conjunction with a short ground traverse from either side of the range, to establish the age of these rocks.

The base plans were prepared from aerial photographs using the slotted template method, and all available trigonometrical control. This work, together with the draughting, was carried out by the Survey Section of the Hydro-Electric Commission.

At the time of mapping, little vertical control was available throughout the area and a number of spot heights from aneroid readings were obtained. These heights, together with more recently established bench marks, are indicated on the geological plans.

Physiography

The eastern portion of the area consists of steep, rounded, basalt hills north-east of the Derwent. West of the Derwent the country rises steeply at first, to an elevated plateau which slopes gently north-north-east from the Misery Range to the hills forming the west bank of the Derwent. Further west from Mt. Misery, the country falls abruptly to the floor of the Florentine Valley, which reaches a maximum width of about 3 miles near the Settlement. Further downstream from this point, the valley becomes much narrower where the river passes through a dolerite gorge. The west wall of the Florentine Valley is formed by the eastern slopes of the Gordon Range, and the area between the Florentine and Rasselas Valleys is occupied by this Range. The Gordon Range consists of a series of high, parallel, hogback ridges formed by the outcrop of steeply dipping Eldon Group rocks. The Rasselas Valley, occupied by the Gordon River, is a typical button grass plain, a common feature in the south and south-west of Tasmania.

The physiography of the area is controlled closely by the composition and structure of the underlying rocks.

The Derwent Drainage Area.

The steep rise in elevation to the west of the Derwent, is due to the upthrown dolerite sill, which reaches a maximum elevation of about 2500 feet at the Misery Range, and slopes back gently from this Range to the complex post-dolerite fault system running north-north-west along the west bank of the Derwent. East of this fault system, and running parallel to it, is a further fault which is downthrown to the south-west, thus forming a structural trough along which the present Derwent River runs.

The trough has been filled by Tertiary lake sediments and basalts. The latter, in one case, has overflowed the trough, flooding part of the country to the north-east. The Derwent River was born as a result of the post-dolerite faulting, at first as a series of lakes along the floor of the trough, in which it deposited clays, sands and gravels. The later basalts filled the trough so that the course of the Derwent was modified, probably being controlled by the distribution of the various lava flows, and any older rocks which may have protruded through the basalts. This course has since been deeply incised into the underlying Triassic sediments and dolerite.

All the tributaries which join the Derwent from the west are young streams with steep gradients whose courses are strongly influenced by fractures within the uplifted dolerite block. The tributaries from the east have rather more complicated profiles. Where they tumble down over the eastern escarpment of the trough, they are young active streams. Where these streams flow along the trough they have the characteristics

of mature streams but become young and active once again as they fall sharply into the Derwent. The Derwent has been able to cut more deeply into the floor of the trough than these small tributaries, thus causing the steep profiles near the junction of these streams.

The Florentine Drainage Area

The Florentine River shows two quite distinct profiles. In the upper part, where the river flows through limestone, it is quite flat and relatively mature. Downstream of this, the river flows first over Permian then Triassic sediments, and finally Jurassic dolerite, before joining the Derwent. The river becomes increasingly steep and exhibits all the features of a youthful stream.

Further interesting features of this valley in its upper reaches are that whilst it has a broad, flat section similar to the Rasselas Valley, its floor is about 200 feet lower, also the valley is never quite as mature as the Rasselas because the base level of erosion is being continually lowered just fast enough to prevent the development of an entirely mature valley.

Loftus Hills (1921) and Twelvetrees (1908) have both reported relicts of high level river terraces, probably higher up the valley and outside the area mapped. The vegetation in this valley is also indicative of its state of maturity. It should be noted that the dense vegetation is due to better drainage in the Florentine than in the Rasselas Valley.

Taking these facts, together with the structure and topography, an interesting picture of the development of this valley emerges. The Florentine River was initiated shortly after the final movements of the Tertiary epeirogenesis. It was first formed in a small, structural trough in a downthrown block between the Gordon Range and the Misery Range faults. Possibly at an early stage it flowed due west through the gap between the Gordon and Tiger Ranges and joined the Gordon River slightly upstream of the present Big Bend. Its development was arrested by quartzite bands in the Eldon Group rocks and a tributary of the Gordon, cutting back around the end of the Tiger Range in limestone, eventually captured it and for a while it flowed on an almost exactly opposite course to the present one. In other words, the present Huntley River would be the beheaded remnant of a stream which formerly had its watershed on the Misery Range.

This course persisted for some time but the development of the Gordon River and its tributaries above the Big Bend was slowed down by a resistant bar of Owen Conglomerate between the Thumbs and Mt. Wright. At the same time, a young and very active tributary of the Derwent, now the lower part of the Florentine, was cutting its way back along a series of shears towards the head waters of the Florentine River at that time. Eventually this stream captured the Florentine and because it has been able to lower its base level more rapidly through dolerite than the Gordon has been able to cut through the Owen Conglomerate, it has completely reversed the drainage of the Florentine, lowered the base of the Florentine Valley faster than of the Rasselas Valley, and will very soon capture the head waters of the Gordon itself.

The Gordon Drainage Area

The Gordon River, where it flows through this area, meanders in a mature fashion across the broad floor of the limestone Rasselas Valley. The limestone, for the most part, is obscured by superficial deposits of Pleistocene fluvio-glacial deposits and Recent river gravels. Tributaries of the Gordon arising in the Gordon Range, show well developed, rectangular drainage pattern typical of folded rocks.

Stratigraphy

Although more than half the area is covered by intrusive dolerite, sediments ranging in age from Ordovician to Recent are exposed:—

		Approximate Thickness in feet.
Recent:	River gravels and fluvioglacial deposits	
	DISCONFORMITY	
Tertiary:		
	Basalts	1,300
	Fault trough lake sediments	300
	UNCONFORMITY	
Triassic:		
	'Feldspathic' Sandstone	260+
	Knocklofty Sandstone and Shale	500+
	Ross Sandstone	300+
	DISCONFORMITY?	
Permian:		
	Ferntree Mudstones	250+
	Woodbridge Glacial Formation	250
	Sandstones and Mudstones	100
	UNCONFORMITY	
Siluro-Devonian:		
	Eldon Group	4,000
Ordovician:		
	Gordon Limestone	5,000

All the rocks older than the Permian have been folded, and show evidence of having suffered at least two periods of earth movements. Owing to the lack of fossil evidence in the Triassic sediments and the absence of any sediments between the early Jurassic and Lower Tertiary, the age of the dolerite cannot be accurately determined. The writer has followed the Geological Survey, Hills and Carey, and others, in assuming that the dolerite is of Jurassic age. Similarly, the age of the basalts cannot be fixed precisely but there is no clear reason to insist that they are older than Tertiary.

Gordon Limestone

Limestone was first reported in this area by Gould (1861, footnote). Later, Twelvetrees (1908) reported that the Gordon Limestone in both the Rasselas and Florentine Valleys and described it as Lower Silurian (Ordovician) age, and recognised the synclinal structure. Hills (1921) also described the limestone in both valleys, but assigned a Silurian age to the formation.

Recent work on this formation in the Zeehan area by Gill (1950), tends to confirm the age as Ordovician, but with some reservation. Hills and Carey (1949) ascribe an Ordovician age to the formation and suggest that it ranges from the Lower Ordovician to near the top of the Ordovician. Fossil determinations by Opik (1951) from material collected in the Florentine Valley suggest an age ranging from Middle to Upper Ordovician, but the bottom of the formation is not well exposed, and is complicated by the Misery Range fault, the position of which is difficult to locate exactly.

The lithology of the formation varies considerably from pure limestones through arenaceous and argillaceous varieties, to slates and sandstones. The exact proportions of the impure types is difficult to determine because of the poor outcrops, but certainly, in this area, slates and sandstones form minor proportions. The limestone is a dense, blue-grey rock containing occasional nodules of pyrite; it has a distinctive, fetid odour when freshly broken. The impure varieties have a banded or foliated appearance in outcrop, and split with difficulty along the impure bands. Fossils are frequently found on the weathered faces, in a good state of preservation, apparently being less soluble than the limestone. The formation is fossiliferous throughout, but certain horizons are more fossiliferous than others.

In outcrop, the rock exhibits solution flutings. It is closely jointed in general, and intensely sheared in the vicinity of the faults. The deposition of calcite as veins along joints is common. The rock weathers to a black to reddish, ferruginous loam which is highly fertile where adequately drained. Deep weathering is a feature of this limestone throughout the west and south-west of Tasmania. For this reason, there is always a marked lack of outcrop in limestone areas, and this is particularly so in the Rasselas Valley where the residual soils form a grey-black pug overlain by extensive alluvial deposits. Underground drainage is common in both valleys, and many caverns and sink holes occur in the Florentine Valley. The caverns consist of solution openings along both joints and bedding planes, but with a preference for the joints. They cannot be traced for any distance on account of the low relief and high water table.

The width of the limestone outcrop in the Florentine Valley is about 11,000 feet and the average dip is about 30°. This gives a very approximate thickness of about 5000 feet.

The limestone is overlain by the Eldon Group rocks, apparently conformably, but the outcrops are too poor to discount the possibility of a disconformity between the two groups, as suggested by Gill (1950). However, there appears to be no great change in strike between them. The formation is overlain unconformably by the Permian rocks, which form the base of the Misery Range. No older rocks than the limestone are exposed in this area.

Eldon Group

These rocks form the Gordon Range lying between the Florentine and Rasselas Valleys and reach an elevation of about 2500 feet. As

mentioned above, they appear to overlie the Gordon Limestone conformably. The rocks are folded into a syncline and outcrop as a series of steep, hogbacked ridges, which are particularly suitable for photo-geological interpretation. They have therefore been mapped by this method in conjunction with a short traverse into the basal member, from either side of the Gordon Range. Fossils found on these traverses have definitely established the rocks as belonging to the Eldon Group, but no definite correlation has been made with the formations of the Eldon Group.

The basal member of the group consists of interbedded, white quartzite and friable sandstones, with occasional gritty and conglomeratic bands. It contains some indistinct tubicolar structures and at least one band packed with poorly preserved crinoid columals.

The rocks are folded into a broad syncline which pitches gently to the north and is cut by a series of faults. These rocks were first described by Twelvetrees as " sandstones of undetermined age " and later by Hills as Silurian sandstones. The most recent work by Gill (1950) places the age as ranging from Middle Silurian to Lower Devonian. A very rough determination of the thickness of the group from the known dips and width of outcrop, gives a thickness of the order of 4,000 feet.

Permian System

Rocks of this age outcrop under cover of dolerite along the east side of the Florentine Valley and south facing slopes under Wylds Craig. Over all this area the exposures are partly obscured by a cover of scree derived from the overlying dolerite sills. No complete section has been mapped in the area, but no doubt, with careful field work, the individual formations could be mapped.

The best exposure of the Permian strata is in the bed of the Florentine River about 2½ miles north of the Settlement. Here beds close to the base of the sequence are exposed as bars crossing the river. The lowest rocks are impure, pebbly marls containing poorly preserved gastropods and they are interbedded with, and underlie, quartz sandstones which contain rare, indistinct plant remains. Overlying the sandstones are pebbly mudstones and sandstones with fossiliferous bands. The top member of this is extremely fossiliferous, with zones packed with Spiriferids, Pectinacea and *Martiniopsis*. The pebbles in this formation are predominantly quartz and quartzite but there are also fragments of schist, slate, chert and limestone. The formation resembles the Woodbridge Glacial Formation.

Overlying this last formation is about 250 feet of dense unfossiliferous pebbly mudstone which lithologically resembles the Ferntree Mudstone. However, the outcrops in this formation are very poor as they directly underlie the dolerite sill forming Mt. Misery, and are for the most part covered by scree. Some blocks of sandstone, lithologically resembling the Risdon Member of this formation, have been located in this scree, but this member has not been identified *in situ*.

Taking the field evidence that is available, the section appears to be similar to the Permian section, as described elsewhere, but somewhat restricted in thickness:—

Lithology	Palaeontology	Approximate thickness ft.
Jurassic Dolerite (Intrusive)		
Pebbly Mudstones	No fossils observed	250+
Cherty Mudstone		
Greywacke Conglomerates	Spirifids, Pectinacea	
Pebbly Mudstone	*Martiniopsis, Fenestella*	250
Silty Sandstone	Indistinct plant remains	
Pebbly Marl	Small, poorly preserved gastropods	100
Unconformity		
Gordon Limestone		

There is no evidence to show whether the dolerite capping the Misery Range is intruded at the top of the Ferntree Mudstone or not. If it is, this would make that formation very much thinner here than elsewhere.

The Permian rocks are block faulted, closely jointed and tilted, but are not folded. They are not deeply weathered where exposed, on account of the steep slopes, which cause the rapid removal of products of weathering to form extensive scree deposits mixed with fragments of the overlying dolerite sill.

These rocks overlie the Gordon Limestone with a marked unconformity. The actual junction between the two formations is not exposed, but the field evidence, lithology and structure of the Permian rocks favours the interpretation of this contact as an unconformity, rather than a fault. There is no evidence of faulting at the boundary between the rocks and the shape of the boundary certainly does not favour its interpretation as a fault.

Triassic System

Rocks of the Triassic System are the commonest sedimentary rocks throughout the area, and have been mapped in three of the map squares. The quartz sandstones in this system usually outcrop well, and some sections have been measured, but the shales are usually deeply weathered and outcrops are rare. However, a number of diamond drill holes have been drilled in connection with investigations for the Wayatinah B power development in map square 4477 and these provide a good deal of useful stratigraphic information on this system.

However, despite this drilling, great difficulty has been found in correlating between some of the drill holes, owing to rapid facies variation and to the lensing out of beds over short distances. Apparently little reliance can be placed on colour variation, as this appears to be in part at least, a function of the ground water conditions, and the degree of weathering. The general lithology of the members does not lend itself to definite correlation, as individual members, or even groups of members, cannot be identified with certainty over any distance. Correlation on fossil evidence is unreliable with the present state of knowledge of the plant fossils. Since many such zones are present, fossil zones in themselves cannot be used for correlation.

Whilst the lack of detailed correlations, even with the aid of diamond drilling, is to be regretted, it should be taken as a warning against such correlations based on limited field sections measured in different localities. Extremely detailed investigations in similar sediments carried out for the investigation of various sites for the Warragamba Dam in New South Wales, founded on the Hawkesbury Sandstone, have been described by Browne *et al.* (1951). The sections drawn as a result of those investigations also serve to illustrate the complexity in detail of such sediments.

Despite the difficulty of detailed stratigraphy within the sequence, it is quite clear that at least two distinct formations can be recognised, namely the Knocklofty Sandstone and Shale and the ' Feldspathic ' Sandstone. The basal sandstone member of the Knocklofty Sandstone and Shale is over 300 feet thick, and may well merit recognition as a separate formation. If so, it is equivalent to the Ross Sandstone of Hills *et al.* (1922).

Ross Sandstone

As mentioned above, over 300 feet of this formation has been encountered in drill hole 8525. It consists of cross-bedded, medium-grained, quartz sandstone. In outcrop it is yellow, but in drill cores it is usually grey with some minor purple and pink bands. The sandstone is micaceous throughout and contains some bands, or lenses, of mica up to 2 feet thick. Claystone bands, never more than 3 feet thick, and clay pellet conglomerates are present as thin bands scattered throughout the formation. Occasional beds of coarse sandstone have been recovered in the cores, but none of the above features are sufficiently persistent to be used as marker horizons.

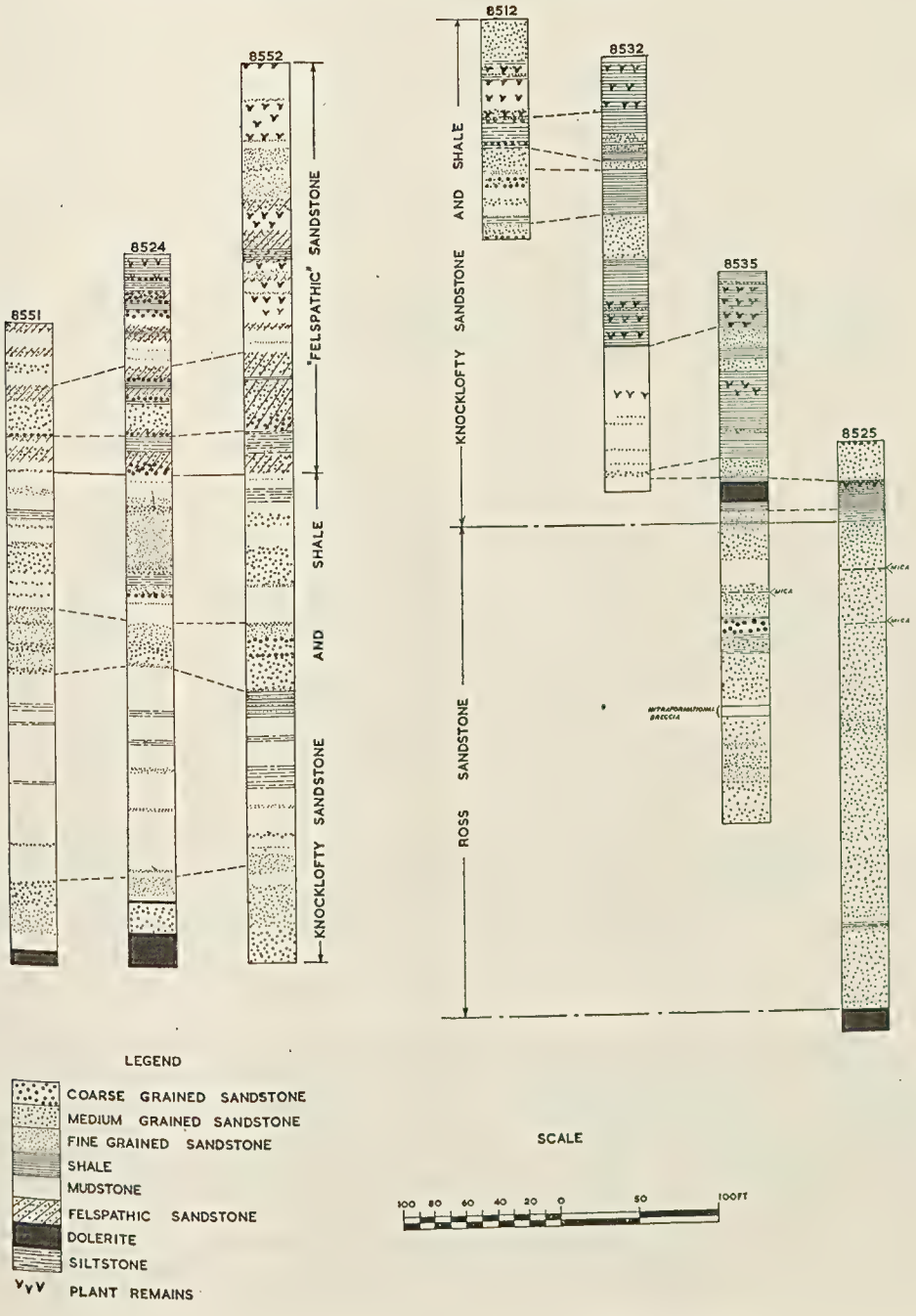
Where this rock outcrops on the east bank of the Derwent, opposite the Florentine junction and along the Florentine River, in the extreme south-west of map square 4477, the sandstone contains sub-angular fragments of milky quartz distributed throughout. These sections may be lower in the formation than the drill cores. The stratigraphy of part of the formation is indicated in the bore logs shown in the text figure.

Knocklofty Sandstone and Shale

Overlying the Ross Sandstone is at least 500 feet of alternating sandstones and shales. The stratigraphic sequence in this formation is broken by the faults indicated on the maps, and the formation could be much thicker than this. Outcrops are poor throughout the area and the stratigraphy is based on the diamond drill cores.

The formation consists of interdigitating sandstones, shales, claystones and mudstones. The sandstones vary from fine-grained and silty types, to coarse grit bands. They are predominantly silicious but the upper sandstone member, just beneath the ' Feldspathic ' sandstone is a ' spotty ' quartz sandstone containing about 10 per cent of kaolinised feldspar. The sandstones throughout are micaceous, and graphite is present along some of the bedding planes. Sedimentary structures are difficult to interpret from the drill cores, but cross bedding is exhibited by almost all the sandstones, and certain of the cores suggest contemporaneous faulting and slumping in the sediments.

GENERALISED BORE LOGS. WAYATINAH B AREA



The argillaceous sediments range in grain size from dense, cherty mudstone, through silty mudstones, siltstones and silty sandstones. Shales and claystone bands interdigitate with the sandstones and are usually thinner than the mudstone members. Between individual beds the boundaries may be either very sharp or gradational. The general colour of the sediments in drill cores is grey, but pink, green, purple, black and white bands are present. The shales and siltstones particularly, are micaceous and contain many fossil horizons. Clay pellet conglomerate bands up to 2 feet thick do occur, but they rarely exceed 6 inches.

The formation apparently behaved as a receptive host rock for the dolerite intrusion, as minor intrusions are common, particularly in the shale members. Near such contacts there is some hardening of the shales, but very little other metamorphism.

The thick bed of dense mudstones encountered in drill holes is somewhat unusual for Triassic rocks. Elsewhere in Tasmania, the argillaceous Triassic sediments are usually thinly bedded, fissile shales. Whilst many such shale beds are present in this area, over 100 feet of hard mudstones are present. The core is a dense, brittle mudstone, dark-grey to purple in colour, with a distinct mottling of purple blotches. Some thin silt and sandstone bands are interbedded with the mudstone. No fossils have been found in this part of the core.

The rock has the appearance of having been hardened by regional metamorphism, but this is difficult to believe in view of the extremely local effects produced by the dolerite elsewhere. They exhibit a degree of lithification almost as high as the Permian mudstones. Since this member has only been located in drill cores, it is difficult to offer any firm explanation for the phenomenon. It may be that this is a more common feature of Triassic rocks than is generally realised but it is masked in outcops by surface weathering. Drill holes of comparative depth through Triassic sediments in other parts of the State have not revealed similarly hardened mudstones, but all such holes of which the writer is aware may have been somewhat higher in the Triassic System.

As previously mentioned, no sign of coal seams has been found anywhere in the formation, but plant remains are abundant at certain horizons. No marine fossils have been found whatsoever. The formation passes upwards conformably into the ' Feldspathic ' Sandstone. Detailed stratigraphy of the portions of the formation penetrated by bores is shown in fig. 1.

' Feldspathic ' Sandstone

This formation forms the uppermost beds of the Triassic System, and is overlain unconformably by Tertiary gravel and basalts. Generally, the formation is deeply weathered and covered by basalt scree. The boundary indicated on the geological map has been determined by obtaining approximate structure contours from drill holes, and plotting these on a contour plan of the area. The formation is dislocated completely by the fault cutting across the Wayatinah B tunnel line.

The base of the formation in this area has been taken as the lowest bed of ' feldspathic ' sandstone encountered in the drill holes. However, as there is considerable facies variation and lensing of beds in this area,

the base cannot be claimed as being defined in any way. This gives a thickness of at least 260 feet in this area. A further drill hole north-east of this area encountered 360 feet of feldspathic sandstones under a cover of basalt. However, the structure is not known in that area and some beds could be repeated by faulting.

The formation consists of ' feldspathic ' sandstones ranging from fine to coarse-grained, interbedded with siltstones, shales and mudstones. Many of the shale bands contain plant remains. The shales are fissile and micaceous, and again, like the Knocklofty Shales, usually grey and black in colour but sometimes purple, pink and green.

Analysis of the drill cores shows that colour cannot be used as a criterion for identification or correlation but that the colour variation is a function of ground water conditions and the degree of weathering.

As with the Knocklofty Sandstone and Shale, cross bedding, clay pellet conglomerates, and slump structures are a feature of this formation. Certain of the sandstone bands have a calcareous matrix and effervesce with acid. The portions of this formation encountered in the drill cores is shown in fig. 1.

Tertiary System

In the interval between the intrusion of the dolerite and the Tertiary faulting, lateritic bauxites were formed on those portions of the land surface where the dolerite was exposed. The laterisation probably occurred towards the end of this interval after the highlands had been denuded, and the surface approached a peneplain. This bauxite has been preserved in down-faulted blocks which were quickly covered by Tertiary sediments and basalts. An exposure of such bauxite underlying Tertiary basalts is indicated towards the north-east of map square 4577. The age of this rock is open to some doubt, and its inclusion under the Tertiary System is therefore tentative. The rock is ferruginous, pisolitic and reddish-brown in colour. It overlies the parent dolerite.

Sub-Basaltic Lake Sediments

Overlying the Mesozoic rocks unconformably, and underlying the Tertiary basalts, is a discontinuous series of lake sediments varying widely in thickness and lithology. The sediments occupy the floor of the structural troughs produced by Tertiary faults, and have been deposited very rapidly into the lower basins of these troughs. The rapid accumulation of these sediments is indicated by the poor sorting and sedimentary structures.

In map square 4577, the Tertiary sediments are mainly confined to the north-eastern portion of the square, and are exposed in cuttings along the Tarraleah Highway. The rocks comprise ferruginous sandstones and claystones displaying cross-bedding and slump structures. They are not highly lithified; some of the sandstones have a limonite matrix and contain limonite nodules. Being rather soft rocks, they form no outcrop except in cuttings, but their presence may often be detected by the limonite nodules scattered through a barren, sandy soil. In the exposures along the Tarraleah Highway, the limonite can be seen to be confined mainly to the bedding planes. It has apparently been introduced after the sedi-

mentation, probably from leaching of the overlying basalts. The sediments contain some plant remains including dicotyledon leaves, but to date these have not been used to determine more precisely the age of these rocks. Some rounded gravels similar to those described below in map square 4477 have been mapped underlying the basalts in both branches of Black Bobs Rivulet where the base of the basalt is exposed. The thickness of the Tertiary deposits is variable, and it is estimated it is of the order of 300 feet in this area.

Underlying the basalts at Long Spur in map square 4477 is a fairly widely distributed deposit of well-rounded quartzitic gravels. From their stratigraphic position in relation to the structure, the gravels are of Tertiary age, yet they apparently contain no dolerite boulders. A close inspection of this horizon has revealed boulders of quartz, quartzite, schist, conglomerate, sandstone and basalt. A similar deposit is located in the same stratigraphic position on the extreme eastern margin of map square 4576, near the centre point of air-photo No. 17370 of King William, run 12. Again, in this case, no dolerite boulders have been located. The thickness of the gravels is difficult to assess, as the lower limits cannot be fixed with any accuracy, but they probably do not exceed 30 feet. Very close to the basalt, the gravel deposit has been extensively silicified to form a dense conglomerate (grey billy) superficially resembling Owen Conglomerate. Such material is exposed at the base of the basalts in the east branch of Black Bobs Rivulet on map square 4577, and again on map square 4576, opposite the mouth of the Broad River in the north-east corner of the map square. Blocks of similar material are to be found on the steep slopes under Long Spur.

The formation of such a deposit containing a little or no dolerite is somewhat puzzling in view of the fact that there is abundant evidence to show that much of the landscape at the time of deposition was composed of dolerite. However, one explanation of the formation of the deposit which is consistent with all the evidence available so far is offered:—

> Between the Jurassic dolerite intrusions and the Tertiary uplifts, widespread erosion took place, so that the land surface was reduced to a peneplain on which the bauxites were developed. In the west of the area, Eldon Group rocks projected through the peneplain surface as monadnocks, and further west and south outside the area, near the Thumbs-Mt. Wright area and Tim Shea, were further monadnocks of Owen Conglomerate and older rocks. Around the base of these hills, extensive talus deposits accumulated.
>
> If the first movement of the Tertiary faulting was to uplift the old core of Tasmania by the boundary faults along the Derwent trough, this would tilt the plateau so formed towards this trough. Renewed erosional processes which must have been initiated by this uplift, would quickly strip off the peneplain's lateritic crust and deposit it into the chain of lakes formed along the Derwent. The laterite was probably fairly thin and underlain by clays over the dolerite and Permian rocks, and by sands over the Triassic sandstones. All this material could be quickly eroded and easily transported, and therefore was swept

into the deeper parts of the Derwent trough. As denudation proceeded further, and before the dolerite bedrock was attacked, the outlying talus accumulations of older rocks would be transported down into the trough on top of the sands and clays already deposited. However, once in the trough, the boulders, being more difficult to transport than the finer sediments, would tend to accumulate as disconnected sheets, whose movement downstream would be barred by any lakes.

The basalt extrusions must have occurred before any wide scale erosion of the dolerite plateau had begun. However, basalts must have been extruded elsewhere before those in this area, to produce the basalt boulders in the gravels.

Tertiary (?) River Gravels

Just downstream of the Florentine junction, the Derwent has cut down through a series of old river gravels. These are composed of rounded dolerite pebbles, cobbles and boulders up to 2 feet diameter, in an abundant matrix of weathered dolerite. A good section through this material about 30 feet thick is exposed in the vertical banks of the river here. The deposit certainly belongs to an older cycle of erosion than the present one, but the exact age is open to some doubt, and they may well be Pleistocene. However, their degree of lithification is indicated by the fact that the material stands in vertical faces along the banks of the Derwent where this river is actively entrenching its course.

Basalts

As described earlier, the Tertiary faults were followed after a short interval by a series of basalt extrusions. These are largely confined to the graben-like structure along the Derwent. At one point near the north-eastern corner of map square 4577, the basalts have overflowed the trough and spilled over the fault scarp.

The basalts outcrop as a series of flows; individual flows rarely exceeding 60 feet in thickness. They vary from massive, columnar basalts, through vesicular types to scoriaceous agglomerates. The field characters of basalts in the Tarraleah area have been described by Prider (1948) and his descriptions match the field observations on the basalts in this area. Edwards (1950) has described the petrology of various basalts throughout Tasmania. From this work, he concluded that there were either two periods of volcanic activity, or else that contemporaneous eruptions of two different magmas occurred.

The field evidence in this area is not conclusive for either of Edward's suggestions. However, the rounded basalt boulders described previously in the sub-basaltic gravels show that if there were not two widely separated periods of vulcanism, then at least the period was long enough for erosion of the earlier basalts to have taken place before the basalts in this area were extruded. Certain other field evidence, such as the distribution of the various flows and their respective levels, also suggests two periods of vulcanism. However, the exposures are rather poor and the evidence cannot be taken as strong enough to establish this.

Where the basalts are exposed in a quarry alongside the Tarraleah Highway in map square 4577, lenses of Tertiary clays are interbedded between the various flows. The sediments consist of creamy white clays with indistinct plant remains. The clays have been laid down in depressions on the top of various lavas, and have been covered by later flows. The clays are not more than 6 feet thick, and most of the beds are thinner than this. In the outcrop, they are very irregular in shape, and although weathered, show signs of baking on the upper surface.

The shape of the base of the basalts indicates the pre-basalt topography in areas where the Tertiary lake sediments are thin or missing. For this reason, the boundaries have been mapped carefully where they are well exposed and aneroid heights are indicated along the boundaries at certain points. Further work on the subject of the pre-basalt topography is being carried out by Carey, and no details of this need be given in this paper.

Contact metamorphic effects of the basalts have been noted earlier in connection with the silification of the underlying gravels. Where the basalts are underlain by clays, the metamorphic effects are usually concealed by talus or landslides, which are common near the base of the basalt, due to the presence of plastic clays which give rise to springs. In these areas the mapped boundary of the basalts may be unreliable. Landslides are also evident within the basalt series, due no doubt to interbedded clays such as have been described earlier. Many such landslips are indicated on the geological maps.

The basalt gives rise to a characteristic physiography consisting of bare, steep, rounded hills, usually almost devoid of vegetation. On the aerial photographs, this topography shows up quite distinctly and often the outcrops of individual lava flows can be followed on the photos for over a mile.

The basalts weather to a fertile, red-brown soil, highly prized for agriculture. Under favourable conditions, the weathering may be quite deep but due to the steep hillsides, the soil rarely has a chance to accumulate. Commonly, the basalts form a chain of steep hills bordered on either side by fertile valleys.

Jointing varies widely with the various types of lavas. Some of the more massive flows have fairly well developed columnar jointing as in the bottom flow of the basalts on Black Bobs Rivulet, whilst others exhibit a " hackly " type of jointing as in the quarry by the Tarraleah Highway, and this jointing no doubt led to the selection of the quarry site.

Quaternary System

River gravels occur along all the rivers throughout the area. Those along the Derwent in map square 4477 have been described earlier and are thought to be Tertiary. Downstream of that map square, Recent gravel accumulations along the Derwent, consist almost entirely of a mixture of rounded dolerite sands, gravels, cobbles and boulders, ranging up to over 2 feet in diameter. Some sandstone boulders are present in the area where the river passes through the Triassic sediments, but even there they are not well represented due to the superior hardness of the dolerite boulders. However, the sand-grade material consists largely

of quartz, no doubt derived from the Triassic sediments. Similar deposits are found along the Broad and Repulse Rivers and the lower part of the Florentine River. The Dee River meanders through a wide flood plain throughout the middle part of its course in this area. These river flats are closely cultivated and the composition of the alluvium cannot be determined. However, it is probably similar to that described above but no doubt contains, in addition, basalt boulders from the surrounding hills.

The upper portion of the Florentine River, where it flows through the limestone, is bordered by an accumulation of alluvium, consisting of quartz, quartzite, conglomerate, sandstone, mudstone, schist and limonite. Very little limestone is present in the gravels due to the softness and solubility of that rock. As mentioned previously, relicts of high level terraces have been described by Hills (1921) in the Florentine Valley, but no such deposits have been observed in this area. No doubt the terraces lie somewhat south of here.

Extensive gravel deposits cover much of the floor of the Rasselas Valley and have been described as glacio-fluviatile by both Twelvetrees and Hills. The gravels are composed of older rocks such as quartzite, conglomerate, schist, &c. They are probably Pleistocene in age, as suggested by Hills.

The various marshes indicated on the plans are depressions in the bedrock filled with peaty soil and clays. Other recent deposits include the extensive scree deposits throughout the area, talus, and soil cover.

Intrusive Rocks

Jurassic (?) Dolerite

The dolerite occurs in all map squares, and is by far the most common rock exposed in the region. It occurs mainly as sills or discordant sill-like masses, transgressing through the sedimentary rocks. Two small dykes have been mapped which cross the Derwent River near the mouth of the Broad River.

The most irregular intrusions are those in the Knocklofty Sandstone and Shale, particularly the shale members. In these rocks, the dolerite frequently ramifies through the sediments, forming complex minor intrusions outside the main dolerite mass. Some such intrusions have been mapped in the Long Spur area, and are indicated on that map. Where thick sandstone members are encountered, concordant sills may be formed, but gently shelving intrusions, as in the Wayatinah B area, are still common. The dolerite sill forming the Misery Range is a concordant sill intruded either into the Ferntree Mudstone or at the top of this formation. However, the base of this sill is covered by accumulations of scree, and some minor transgressions may take place.

Contact metamorphism is a very minor phenomenon. Usually no effects are visible in the dolerite 50 feet away from the contact. At the junction the dolerite is very fine-grained, in places glassy, and always closely jointed. It often develops a platy structure running parallel to the contact.

The sediments also, are rarely altered for more than a few feet away from the dolerite contact. A slight hardening of shales is evident, and

occasional thin, quartz veins may penetrate along the joints for a few feet. Some thin, pegmatitic veins within the dolerite masses have been observed. They appear to have been intruded into the main body as a late phase of the cooling process. Frequently, fine grained phases are encountered within the dolerite. They have no apparent relationship to any influences outside the dolerite mass.

The dolerite is well jointed, and exhibits a crude, columnar structure where the edges of sills are exposed. In addition to the cooling fractures, which form the more closely spaced joint pattern of the dolerite, the dolerite sills are divided into large blocks by a system of strong, near vertical joints. These joints appear to be related to the Tertiary fault system, and some of them have been indicated on the geological maps. Close to the Tertiary faults, the dolerite is closely jointed, sometimes developing a similar, platy, joint system to that developed near the intrusive contacts. However, here the chilled margins are lacking.

The dolerite weathers in an irregular fashion. The closely jointed areas near faults are sometimes extensively weathered to at least 100 feet depth, and possibly much more than this. The small fault under Forsters Creek has been shown by diamond drilling to be weathered to at least this depth.

Evidence from other parts of the State shows that such weathering is still extensive at a depth of 400 feet. Drilling and geophysical work on dolerite areas just north of here have disclosed wide areas of deep weathering extending to at least 60 feet below the surface, and apparently unrelated to any structural system. The same conditions could well be expected in almost any part of the area where the dolerite is exposed. At present, no reliable method of predicting such wide scale weathering from surface features is known.

The dolerite gives rise to extensive talus and scree accumulations on steep hillsides. Naturally, the thickness of such accumulations is highly variable, but where investigations have been carried out near this area, an average figure for the thickness of talus deposits would be 30 to 40 feet.

The petrology of the dolerite is described in detail by Edwards (1942) and some petrological work by Prider (1948) describes the chilled margins.

The remnants of the sill which form the cap of the Misery Range is about 600 feet thick, but evidence north and south of this area at Wylds Craig and Mt. Field West respectively indicates that the sill was at least 1500 feet thick, and very probably much more than that.

The age of the dolerite cannot be fixed with exactitude. It post-dated the Permo-Triassic sedimentary cycle which extends high into the Upper Triassic if not actually into the Jurassic. It antedates by a very long period of peneplanation and lateritisation the Tertiary basalts, lake sediments and epeirogeny which commenced early in the Tertiary. The limits of age for the dolerite intrusion are therefore Jurassic to Lower Cretaceous. The common assumption is that it is cognate with the extensive feldspathic tuffs which dominate the upper sediments of the Triassic. This would place the dolerite as probably early Jurassic. Nothing has been found in this region contrary to this view.

Tertiary (?) Dolerite

A small plug of dolerite is indicated near the western boundary of map square 4476 in the Florentine Valley. The plug has been intruded into the Gordon Limestone and has altered the limestone in its vicinity. It is now surrounded by a " halo " of limonite, the approximate boundaries of which have been indicated.

The age of this intrusion is open to some doubt as no petrological work has been done on the rock. In hand specimens, it is a fine-grained, closely jointed, blue-grey rock containing phenocrysts of olivine. The presence of olivine appears to relate it to the Tertiary basalts rather than the Jurassic dolerites, as the former are frequently olivine bearing, whilst the latter tend to be tholeitic in composition.

Structural Geology

Structure of the Pre-Permian Rocks

In Map Square 4376, the Eldon Group rocks and the Gordon Limestone are folded into a broad syncline pitching gently to the north. The eastern limb of the syncline is cut by several faults, the major one being the Gordon Range fault. This fault is clearly shown on the air photos where it cuts the Eldon Group rocks north-west of the Settlement. The syncline opens up considerably north of the fault and the rocks show clear signs of warping. The fault is not exposed in the Florentine Valley because of the poor outcrops in the limestone but there is a distinct change in strike and a flattening of the dip in its vicinity.

In contrast to the clearly defined rupture where the fault cuts the eastern limb of the syncline, there is no sign of a corresponding break in the western limb, and the fault has been indicated as turning slightly north and running along the axis of the syncline.

The age of the fault is open to doubt. It has a similar trend and throw to the Tertiary faults but unlike these faults has warped and folded the rocks. This seems to indicate that the rocks were deeply buried at the time of faulting and would place the fault as older than Tertiary. Also, the associated fractures can be clearly seen cutting the Eldon Group rocks and striking straight into the Permian but no corresponding faults have been found in those rocks. If this is correct, the Gordon Range fault is pre-Permian and probably dates from the time of the folding, that is, presumably, Devonian. The associated fractures are difficult to locate in the limestone; they may not actually extend as far as the Permian rocks. Until further evidence is available the age of this fault is best left in abeyance.

The Permo-Triassic rocks have been broken by the dolerite intrusions with their concomitant faulting. These rocks have later been broken and tilted by the Tertiary epeirogeny.

Structure of the Dolerite Intrusions

The dolerite forms vast sill-like intrusions in the Permo-Triassic rocks, frequently transgressing across the bedding, forming shelving intrusions. Dykes appear to be uncommon and only two small dykes crossing the Derwent near the mouth of the Broad River have been observed.

In general, the dolerite has pried its way upwards through the sediments, uplifting many of them in the process as huge rafts which are now completely surrounded by dolerite.

The boundaries of such sedimentary blocks may be steep, nearly vertical fault-like contacts, or gently shelving intrusions. In the former cases, drag dips can usually be observed in the sediments, indicating that they are upthrown with respect to the dolerite. Occasionally, further movement has occurred along these boundaries during the Tertiary epeirogeny.

Some of the faulting has broken the Permo-Triassic sediments but not the dolerite. These are regarded as being associated with an early phase of the dolerite intrusions and include the fault obliquely crossing the Wayatinah B tunnel line and the fault in the extreme south-west corner of map square 4477, which brings the Permian and Triassic rocks into juxtaposition.

The dolerite appears to have been driven up through the older rocks by virtue of its lower density but upon reaching the Permo-Triassic sediments, which apparently had a density close to the molten magma, it began to intrude these rocks wholesale. As a broad generalisation, to which exceptions can be found, the dolerite behaved in a most irregular manner in the softer shales, but tended to horizontal and vertical contacts forming dykes or sills in the more competent sandstones and mudstone beds. However, the dolerite follows no predictable rules and almost any shape of boundary and form of intrusion seems to be possible. As mentioned previously, the dolerite ramifies throughout the shale beds in a most complex manner and in these cases only the general shape of the boundaries has been indicated.

Rafted blocks have been mapped in several of the map squares. In particular, the blocks on map square 4576 have steep, probably almost vertical contacts resembling normal faults but having chilled margins on the dolerite side and very limited baking and quartz veining in the sediments.

The sediments around Long Spur are also a rafted block and the structure of this is known quite well from investigations carried out by the Hydro-Electric Commission in connection with the Wayatinah B Power Development. Structurally, these sediments consist of a large block having the approximate dimensions of 3 miles square, surrounded on all sides and underlain at shallow depths by dolerite. Portions of the southern and western margins of the block are obscured by alluvium and basalt respectively, but the remainder are well exposed and have been mapped in detail and investigated by means of diamond drilling and geophysical methods. The north and west margins are dolerite intrusions which shelve gently under the sediments, and the continuation of the dolerite under the sediments has been shown by gravity surveys and by diamond drilling. The slope of the dolerite surface under the sediments is in general quite gentle, probably averaging about 10°. However, it is not a plain surface and many irregularities, some probably due to the irregular nature of the intrusion, and some perhaps to small Tertiary faults, are present. Just outside the north margin of map square 4477 a portion of this boundary has been investigated in close detail by drilling,

resistivity and seismic refraction work. Contours drawn in the top of the dolerite surface indicate that in detail this surface is quite irregular and there is no reason to believe that this is unusual elsewhere under the blocks. During the rafting process, the block has been broken by at least two faults as shown on the plan, and some dolerite has penetrated to the present surface as minor intrusions above the main dolerite mass. Some other sills likewise intruded above the main mass have been encountered in the drilling in this area.

The portion of the eastern boundary of the block which is not covered by basalt is an almost vertical fault-like contact. It has been exposed in a test pit near the proposed Wayatinah B Power Station site. Also its trace on the map indicates that this contact must be very steep. Where exposed the dolerite is closely jointed, glassy and partly decomposed for some distance from the contact. The Triassic shales and siltstones at the contact are also closely jointed, sheared and highly contorted. The contact zone is about 3 feet wide due to the complex nature of the contact and the lit-par-lit injection of the sediments by dolerite in this zone.

Structure of the Dolerite Plateau

Regional evidence attributes the Tertiary faulting to isostatic adjustments following the removal of material between the time of the dolerite intrusions and the Lower Tertiary. That is, these faults are all uplifts of the higher blocks and not depressions of the low blocks. It is interesting to note that the faulting parallels the fold structures in the Eldon Group rocks. These rocks have been buoyant since the end of the Devonian and the Permo-Triassic sediments thin out in that direction. In fact, it is not established that any Permo-Triassic sediments were deposited south-west of this area. The pattern of the faulting indicates that this area was again buoyant in the Tertiary being the first to adjust itself and being uplifted the most.

The Tertiary faulting has a pronounced south-south-east trend, all the major structures having the greatest displacement run in this direction. At right angles to these structures is another set of fractures having, in general, less displacement along them. The overall pattern of the faults to the west of the Derwent is of a set of south-south-east trending step faults which generally downthrow to the north-east. These have formed a series of roughly parallel blocks tilted towards the Derwent. However, none of the step faults is confined to a single line but is rather a complicated series of faults. A narrow block bounded on either side by such a fault system must inevitably be subjected to complicated stresses during uplift. This tendency to warp the blocks has been taken up by the north-east trending adjusting faults. Because of their origin these faults have, as may be expected, complicated displacements. Some of them are rotational and few of them have the same throw over their full length.

Taking the whole of this uplifted dolerite area as a unit, several interesting features emerge. The fault system of map square 4576 forming the north-eastern boundary of the dolerite plateau has its greatest throw in the south-west corner. However, there is regional evidence of rotational movement in an opposite direction by the Misery Range fault. The warping stresses within the included block have been relieved by rotational movement along the Islet Creek fault.

Adjustments between the individual faults have been taken up in part by smaller faults and in part by differential later movement along the original faults. This is indicated by a series of faults on map square 4476 near the principle points of air photos 17380, 17381, and 17382 King William, run 12. Here, two almost parallel north-north-west trending faults have cut two other almost parallel north-east trending faults. The adjustment between the north-east faults has been achieved by further movement along the portion of the north-north-west fault caught up between them. This movement has in turn tended to warp the small block between the two north-north-west faults and a further adjusting fault has cut this block obliquely. This kind of behaviour points to the extremely brittle nature of the dolerite block. It seems that every small difference of movement has been accounted for by faulting.

The Derwent Graben

East from the Derwent River the Permo-Triassic sediments are again broken by south-south-east trending faults. This one, however, is upthrown to the east, thus forming a graben structure between this fault and the north-east marginal faults of the Misery Plateau. Tertiary sediments and basalts have accumulated within the graben and in some places spilled over the marginal fault scarps. The symmetry of the graben is broken in map square 4477 where the western boundary is disrupted by the fault running east along the Derwent River from the mouth of the Florentine River. However, the general shape of the structural trough is still retained. Since the floor of the trough is now concealed beneath the basalts and Tertiary sediments it is difficult to reconstruct its shape immediately after the Tertiary faulting. The abundant cross faulting in the uplifted blocks leads one to suspect that the floor of the trough is similarly broken and it is pictured as a depressed area trending north-north-east in a series of steps.

Misery Range Fault

Although this fault has a profound geographical expression when viewed from the west, field evidence suggests that there has been comparatively small movement along it. Its physiographic expression is due to the fact that it established the early Florentine drainage and enabled the underlying limestones to be exposed. It is to the soluble nature of the limestone more than to the Misery Range fault that the present valley is due. The Misery Range fault is of Tertiary age. It is downthrown to the west in this area as shown by the rise in the base of the Permian sediments and by the steep dips in the Gordon limestone near the fault. The probable extension of this fault south of the area would run to the east of Mt. Field West and in that area it is downthrown to the east. Thus, this fault when considered along its full length appears to be a rotational fault.

Islet Creek Fault

The Islet Creek fault is the major adjusting fracture in the uplifted dolerite sill forming the Misery Plateau. This fault dislocates all the north-north-west trending fractures. At the north-east end of the fault it is a normal fault downthrown to the south-east. Midway between the

Derwent River and the Misery Range it has little throw and is difficult to trace. The south western end of this fault has less downthrow to the north-west than its opposite extension had to the south-east. The difference in throw at the south-west end is due to the fact that the throw is here divided among a series of small faults all of which cut the north-north-west trending fractures.

The North-East Boundary Faults of the Misery Plateau

This boundary is formed by a complicated series of faults running roughly in echelon fashion. As one fault dies out another one, usually west of it, takes up the throw, eventually dying out to be replaced by a fault further to the west again.

At the eastern edge of map square 4576 the majority of the throw is on the fault which brings the Triassic sandstones against dolerite and crosses the Broad River just north-west of the principle point of photo 17370, King William, run 12. Further north-north-west along this fault the throw diminishes and where it crosses the Repulse River it is a zone of distributed shearing, probably without much throw. As this fault passes from a normal fault to a shear zone the throw has been taken up by the next fault back. This is the fault running roughly parallel to the Dawson Road north-west of the Repulse River crossing. Although this fault can be traced to the eastern edge of the map square the throw is quite small up to the point where it brings the Knocklofty Sandstone into juxtaposition with the dolerite. North-north-west from there it assumes most of the throw of the fault east of it but begins to die out again by the time it is cut by the Islet Creek fault. Beyond Islet Creek the fault can be traced but is again only a relatively minor fault.

These two major north-north-west trending faults are connected near the eastern edge of map square 4576 by a low angle thrust fault which dips at about 20° to the south-west. The next fault back again runs through the old sawmill on the Dawson Road and can be traced right across that map square. Further north-north-west from here the same kind of echelon faulting forms the boundary of the dolerite block to the west but becomes somewhat more complicated as the adjusting faults assume greater throws.

ACKNOWLEDGMENTS

The geological field work has been carried out as part of the regional mapping programme of the Hydro-Electric Commission and the author wishes to express his gratitude to that organisation for permission to publish this article. The base plans and drafting have been carried out by the Survey Section of the Commission to whom full acknowledgment is due. Professor S. W. Carey introduced the writer to the area and has always been ready with helpful criticism and advice. Further help and advice has always been forthcoming from the staff of the geological department of the University of Tasmania, particularly Mr. M. R. Banks. Mr. G. Hale of the Tasmanian Museum logged many of the drill cores and aided with the correlation of the Triassic rocks in the Wayatinah B area. The Australian Newsprint Mills freely gave permission for the author to use their roads and facilities in the Florentine Valley.

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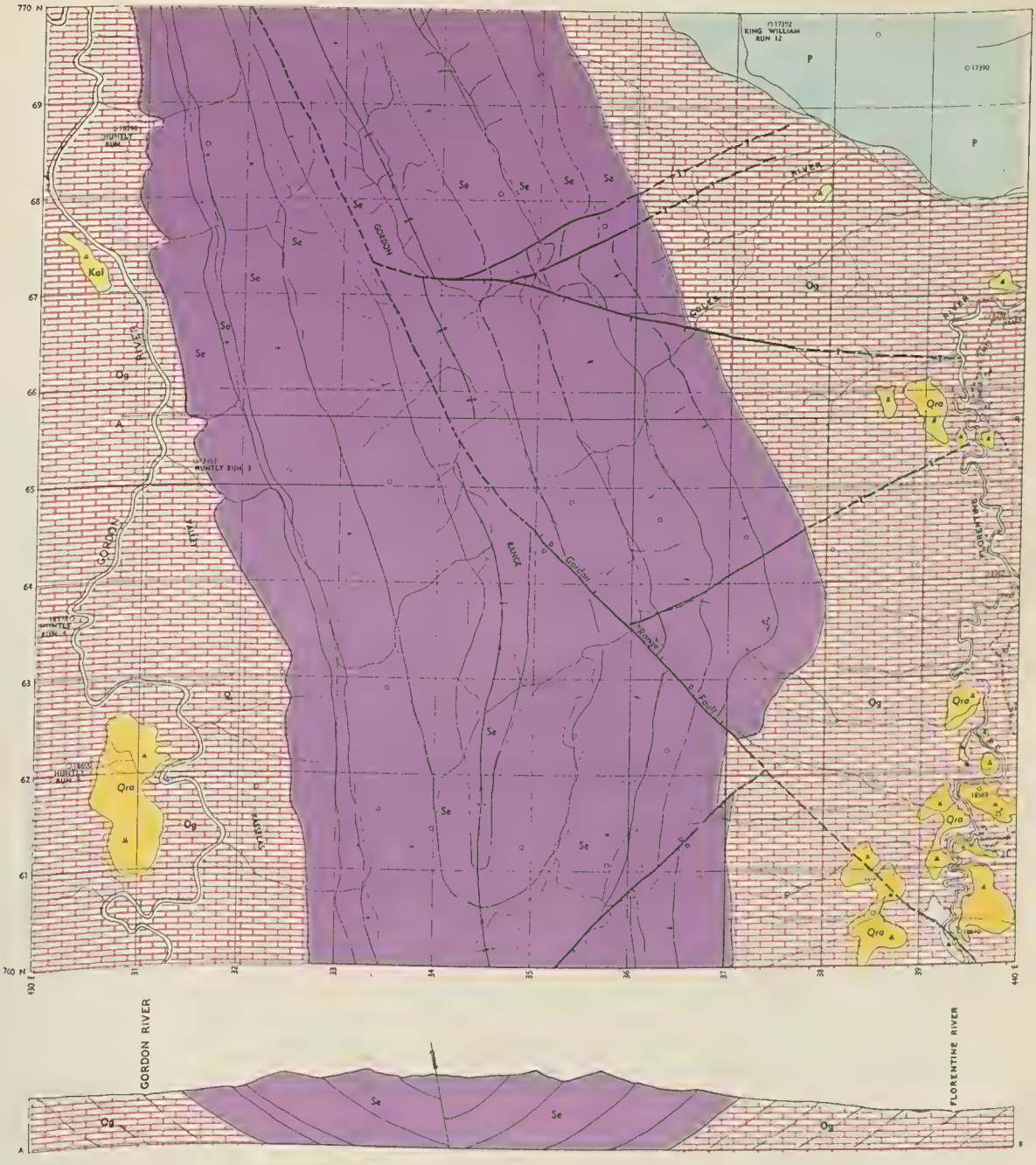
LOCALITY INDEX

	Internat- Grid. Reference K/55 Quadrangle		S.Lat.	E.Long.
Big Bend	Huntly	73	42° 40′	146° 23′
Black Bobs Rivulet	Ouse	67	42° 25′	146° 35′
Broad River	Ellendale	74	42° 34′	146° 38′
Dee River	Ouse	67	42° 21′	146° 38′
Derwent River	Ellendale	74	42° 31′	146° 39′
Florentine River	Huntly	73	42° 37′	146° 27′
Florentine Valley	Huntly	73	42° 37′	146° 27′
Forsters Creek	King William	66	42° 25′	146° 28′
Gordon Range	Huntly	73	42° 31′	146° 24′
Gordon River	Huntly	73	42° 32′	146° 20′
Huntly River	Huntly	73	42° 41′	146° 24′
Islet Creek	Ellendale	74	42° 30′	146° 36′
Long Spur	Ouse	67	42° 25′	146° 34′
Misery Range	Ellendale	74	42° 31′	146° 31′
Mt. Field West	Ellendale	74	42° 39′	146° 31′
Mt. Misery	Ellendale	74	42° 32′	146° 31′
Mt. Wright	Huntly	73	42° 39′	146° 21′
Nive River	King William	66	42° 20′	146° 30′
Rasselas Valley	Huntly	73	42° 32′	146° 20′
Repulse River	Ellendale	74	42° 32′	146° 35′
Settlement (Dawson)	Huntly	73	42° 33′	146° 27′
Tarraleah	King William	66	42° 18′	146° 27′
Thumbs	Huntly	73	42° 41′	146° 20′
Tiger Range	Huntly	73	42° 34′	146° 23′
Tim Shea	Huntly	73	42° 43′	146° 29′
Wylds Craig	King William	66	42° 28′	146° 23′

GORDON RANGE



Quaternary System

Qra MARSH DEPOSITS

Permian System

P UNDIFFERENTIATED PERMIAN SEDIMENTS

Eldon Group

Se Se Se Se Se UNDIFFERENTIATED

Junee Group

Og GORDON LIMESTONE

SCALE

0 2 MILES

0 5000 10,000 FT.

Key Map Showing Magnetic Variation

9.5° E 10° E 10.5° E

Compilation from Aerial Photographs
Trigonometric Station Control by courtesy The Hydro-Electric Commission

Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

Mapped and Compiled by I. B. Jennings.

September, 1954

FAULT INFERRED

FAULT WITH DOWNTHROW INDICATED

FAULT — POSITION APPROXIMATE

FORMATION BOUNDARY

FORMATION BOUNDARY POSITION APPROXIMATE

SYNCLINAL AXIS

TREND OF OUTCROP

STRIKE AND DIP

VEHICLE TRACK

TRACK

BENCH MARK

THE GEOLOGY OF THE GORDON RANGE.

SHEET 43-76.

PHYSIOGRAPHY.

The Gordon Range runs northerly through the centre of the map square with the flattish floored valleys of the Gordon and Florentine Rivers on either side. The range consists of cuestas and hog-backs of Eldon Group rocks. The Gordon River flows in a mature plain with swamps to the west of the range. The tributaries flowing into the Gordon from the Gordon Range are in mountain tract and show a well-defined trellis pattern. The Florentine River flows in a mature valley to the east of the range and its tributaries from the Gordon Range also show a trellis pattern.

STRATIGRAPHY.

Gordon Limestone of Middle and Upper Ordovician age occurs in the floor of the Gordon and Florentine Valleys. It is richly fossiliferous on some horizons near Benjamin and contains some sandy beds. It is overlain by quartzites and shales of the Eldon Group with a basal sandstone with tubicolar structures which may be the Crotty Quartzite. About fifteen hundred feet of Permian sediments overlie the Gordon Limestone unconformably. The basal beds are arkosic followed by limestones with interbedded quartz sandstones, and these are followed by sandstones, conglomerates and pebbly mudstones.

STRUCTURE.

The dominant structure is a northerly plunging syncline, symmetrical at the southern boundary of the sheet but asymmetrical further north due to the effect of the Gordon Range Fault which trends north-westerly at first but then runs north along the centre of the syncline. This fault and its associated minor faults are considered to be Tertiary in age. Flat-lying Permian sediments overlie the Gordon Limestone unconformably.

ECONOMIC.

Immense reserves of limestone are present in the Florentine Valley and road metal could be quarried from the Crotty Quartzite on the eastern side of the Gordon Range.

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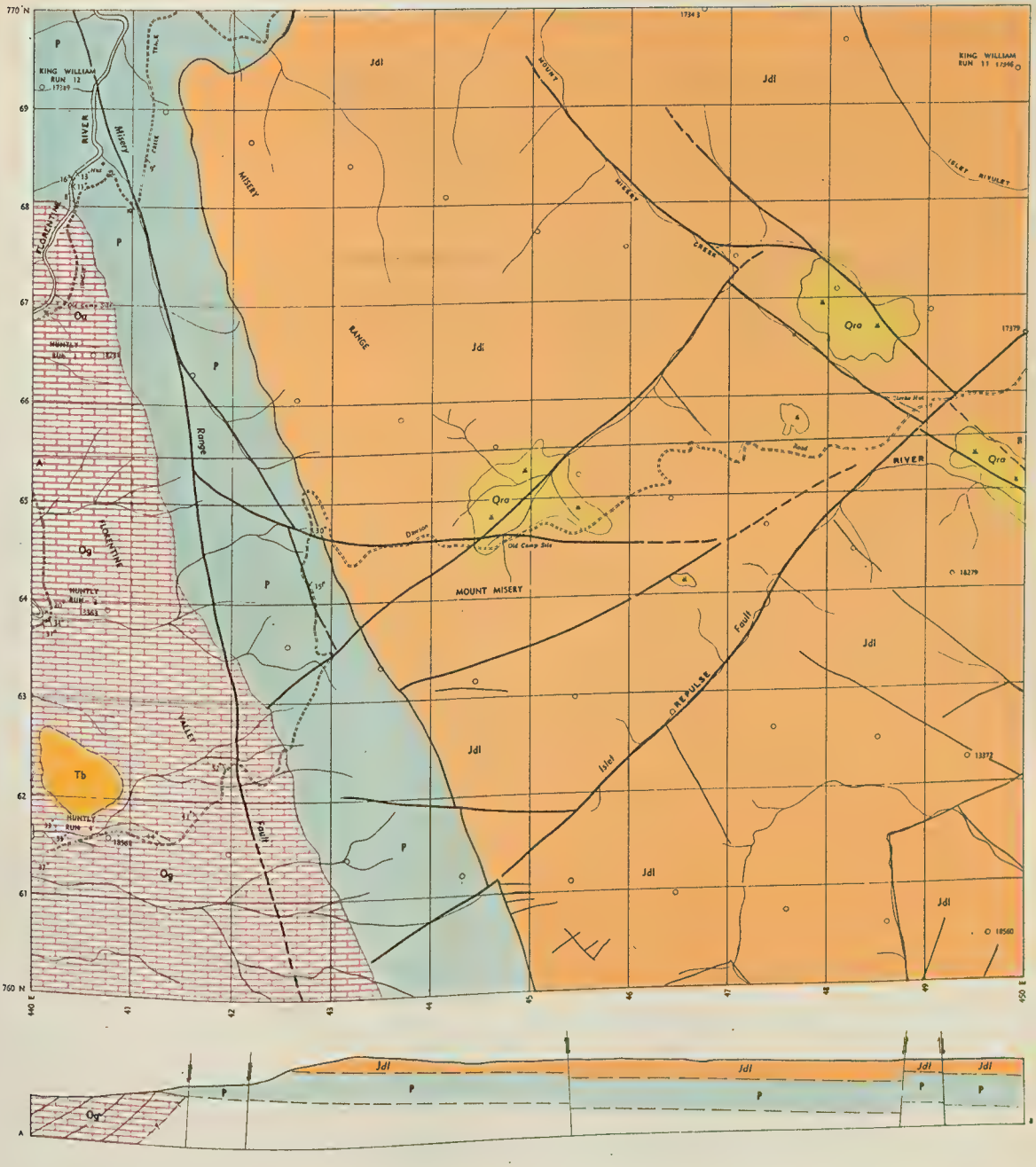
MISERY RANGE

44-76



Quaternary System

Qra MARSH DEPOSITS

Permian System

P UNDIFFERENTIATED PERMIAN SEDIMENTS

Junee Group

Og GORDON LIMESTONE

IGNEOUS ROCKS

Tertiary System

Tb BASALT

Jurassic System

Jdl DOLERITE

SCALE 2 MILES

0 5,000 10,000 FT.

Key Map Showing Magnetic Variation

8° E

10° E

Compilation from Aerial Photographs
Trigonometric Station Control by courtesy The Hydro-Electric Commission

Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

Mapped and Compiled by L. B. Jennings

September, 1954

FAULT

FAULT — POSITION APPROXIMATE

FORMATION BOUNDARY

FORMATION BOUNDARY POSITION APPROXIMATE

STRIKE AND DIP

DOLERITE BOUNDARIES

CONCORDANT SILL

VEHICLE TRACK

TRACK

GEOLOGY OF MISERY RANGE.

SHEET 44-76.

PHYSIOGRAPHY.

Low hills occur on the floor of the Florentine Valley east of Benjamin and to the north-east give rise to the steep talus slopes and sub-vertical dolerite cliffs of the Misery Range. From the top of the Misery Range the surface falls gently to the north-east towards Islet Creek. Caves are common in the limestone of the Florentine Valley. The Florentine River has a mature, meandrine course on the limestone but enters a mountain tract where it flows onto Permian sediments. Drainage on the dolerite plateau north-east of the Misery Range is very immature and swamps are common.

STRATIGRAPHY.

Richly fossiliferous Gordon Limestone of Ordovician age outcrops in the Florentine Valley, especially near Benjamin. The Gordon Limestone is overlain unconformably by about 1500 feet of Permian sediments with limestones, glacial beds and mudstones. The Permian sediments are intruded by a sill of dolerite forming the top of the Misery Range. A small plug(?) of olivine basalt outcrops near the south-western corner of the map square.

STRUCTURE.

The Gordon Limestone dips steeply west and is overlain by a conformable sequence of Permian sediments dipping N.E. at about 10°. The Florentine Valley originated as a graben between the Gordon Range Fault, downthrowing to the north-east and the Misery Range Fault downthrowing to the south-west. The faults are post-dolerite in age.

ECONOMIC.

Extensive deposits of limestone are available in the Florentine Valley. Limestone, Permian sandstones and mudstones and dolerite could all be used for road metal.

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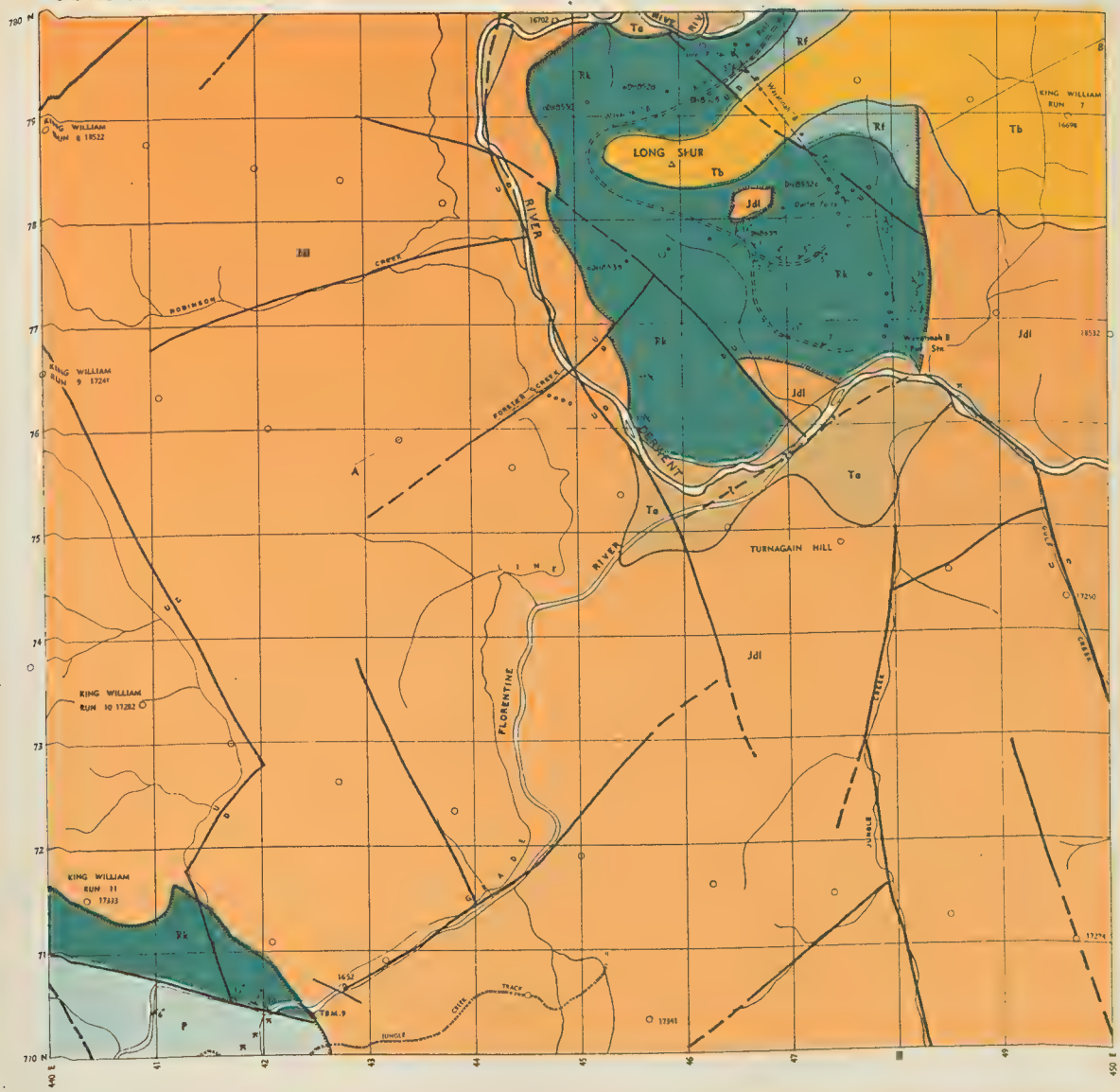
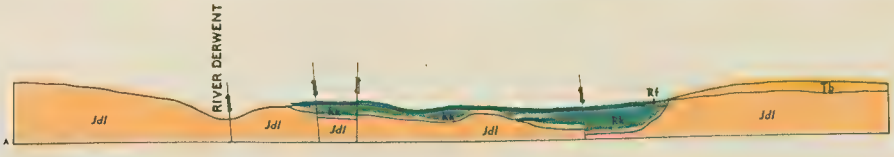
LONG SPUR

44-77





Tertiary System
- To RIVER GRAVELS

Triassic System
- Rf FELSPATHIC SANDSTONE
- Rk KNOCKLOFTY SANDSTONE AND SHALE

Permian System
- P UNDIFFERENTIATED PERMIAN SEDIMENTS

IGNEOUS ROCKS

Jurassic System
- Jdl DOLERITE

Tertiary System
- Tb BASALT

SCALE

0 1 2 MILES

0 5,000 10,000 FT.

Key Map Showing Magnetic Variation.

Compilation from Aerial Photographs
Trigonometric Station Control by courtesy The Hydro-Electric Commission
Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

Mapped and Compiled by I. B. Jennings
September, 1954

- FAULT
- FAULT — POSITION APPROXIMATE
- FORMATION BOUNDARY
- STRIKE AND DIP
- DOLERITE BOUNDARIES
- DISCORDANT INTRUSIVE BOUNDARIES
- DISCORDANT INTRUSIVE BOUNDARIES WITH CONCOMITANT FAULTING
- VERTICAL JOINT
- ROADS
- TRACK
- TRIG. STATION
- BENCH MARK
- ANEROID HEIGHT

N

THE GEOLOGY OF THE LONG SPUR AREA.

SHEET 44-77

PHYSIOGRAPHY.

The Florentine River flows through a steep mountainous gorge in this area to join the Derwent River which is in upper valley tract in this square. The Florentine River and several of its tributaries are partly fault controlled. Most of the hill slopes are very steep especially in the dolerite. The junction of the Florentine River with the Derwent is delayed for about half a mile but the cause of this is unknown.

STRATIGRAPHY.

Permian mudstones and sandstones occur in the south-western corner of this area. Knocklofty Sandstone and Shale occurs also in the south-west and on the lower slopes of Long Spur on which it is overlain transitionally by Feldspathic Sandstone.
These rocks are intruded by dolerite and overlain by flows of Tertiary basalt on the crest of Long Spur. Alluvium occurs in the river valleys.

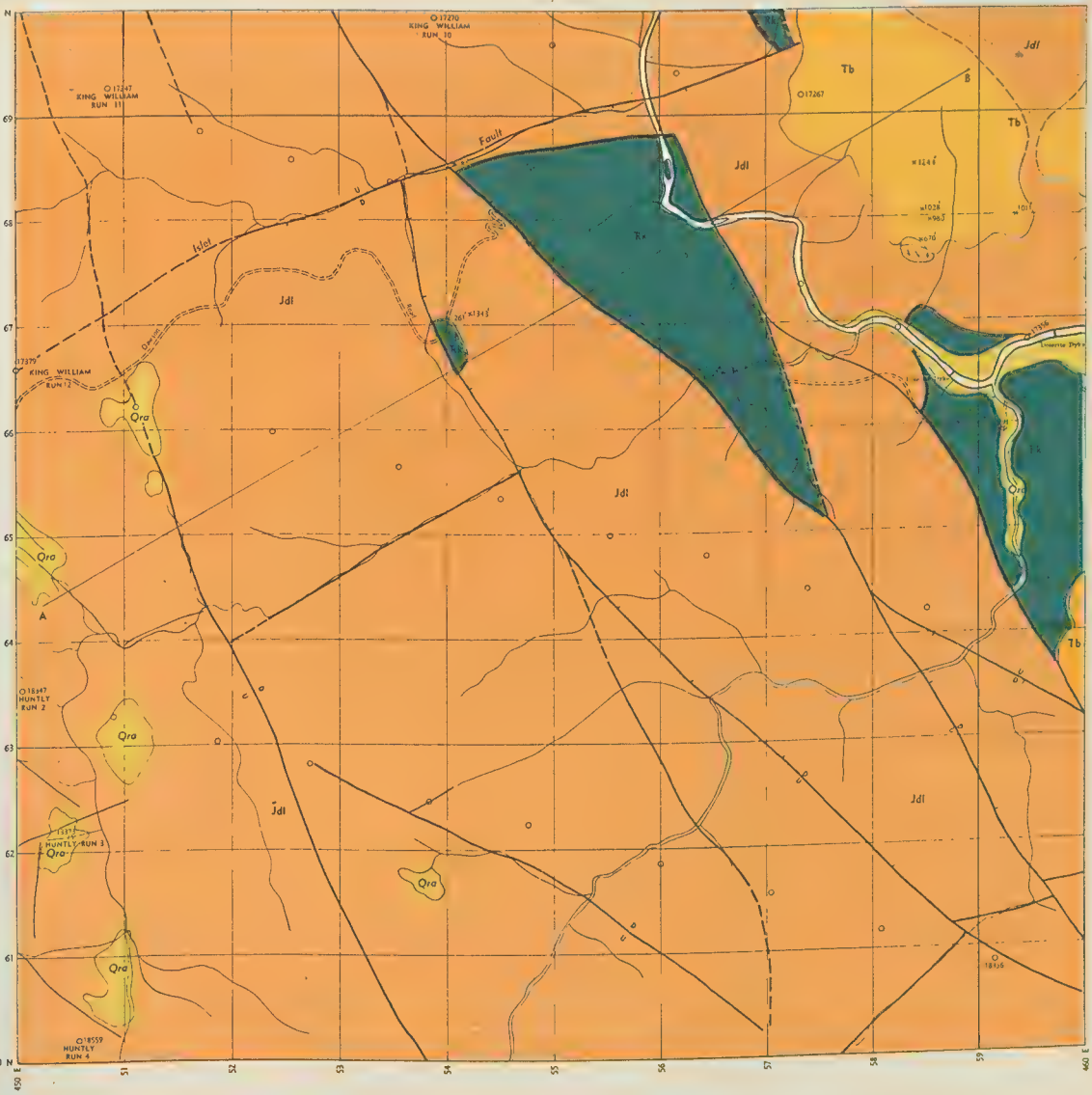
STRUCTURE.

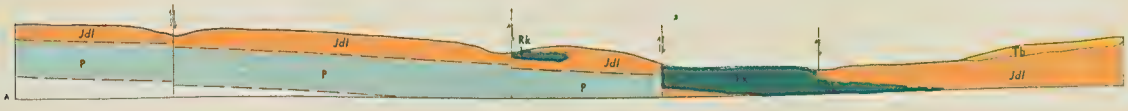
The dominant structure in the area is a normal fault trending just west of north and downthrowing to the north-east along which the Derwent flows in the northern part of the area. There are adjusting faults parallel and perpendicular to this.

REFERENCE.

Jennings, I. B., 1955: "Geology of the Mid-Derwent Area" **Pap. Proc. Roy. Soc. Tas.** Vol. 89.

REPULSE





Quaternary System
Qra MARSH DEPOSITS AND ALLUVIUM
Triassic System
KNOCKLOFTY SANDSTONE AND SHALE
IGNEOUS ROCKS
Tertiary System
Tb BASALT
Jurassic System
Jdl DOLERITE

SCALE
0 1 2 MILES
0 5,000 10,000 FT.

Key Map Showing Magnetic Variation

Compilation from Aerial Photographs
Trigonometric Station Control by courtesy The Hydro-Electric Commission
Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

Mapped and Compiled by I. B. Jennings.
September, 1954

FAULT
FAULT POSITION APPROXIMATE
FORMATION BOUNDARY
FORMATION BOUNDARY POSITION APPROXIMATE
DOLERITE BOUNDARIES
DISCORDANT INTRUSIVE BOUNDARIES
DISCORDANT INTRUSIVE BOUNDARIES WITH CONCOMITANT FAULTING
STRIKE AND DIP
VERTICAL JOINT
VEHICLE TRACK
LANDSLIDE

THE GEOLOGY OF THE REPULSE RIVER AREA.

SHEET 45-76.

PHYSIOGRAPHY.

The area is mainly a deeply dissected youthful dolerite plateau sloping to the N.N.E. into the Derwent and cut by streams such as the Repulse River. The Derwent River is in valley tract with a flood plain developed towards the eastern boundary of the sheet and as many as four terraces. The north-eastern portion of the sheet consists of bare basaltic hills. The Derwent follows a course determined by the Tertiary faulting and the basalt. It follows the south-western margin of a structural trough. The Repulse and Islet Rivers are consequent streams on the dolerite plateau.

STRATIGRAPHY.

The oldest rocks present in this area are massive, cross-bedded sandstones and thinly-bedded micaceous shales of Triassic age. These have been intruded complexly by dolerite in the form of sills near the base and higher in the Triassic, and as dykes. Sub-basaltic clays and gravels of lacustrine and fluviatile origin outcrop beneath basalt at the eastern and north-eastern parts of the area.

STRUCTURE.

The main structure is a conformable sequence of Permian and Triassic sediments dipping N.E. at about 10° and intruded by dolerite sills and some dykes trending mainly just west of north and just north of east. This structure was later broken by faults of Tertiary age trending N.W. with a complementary set at right angles. The north-westerly faults mainly downthrow to the north-east.

REFERENCE.

Jennings, I. B., 1955: Geology of the Mid-Derwent Area. **Pap. Proc. Roy. Soc. Tas. Vol. 89.**

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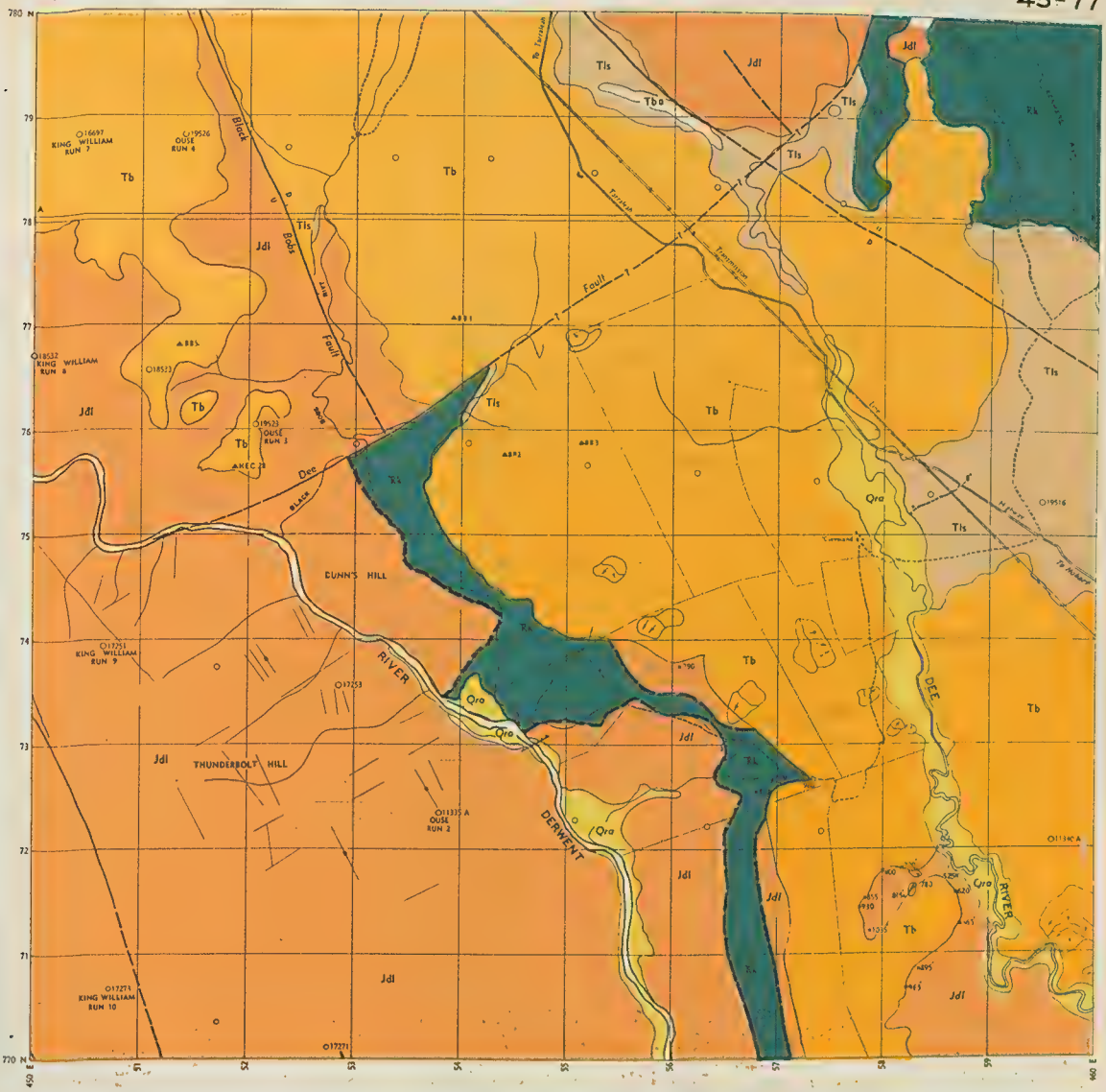
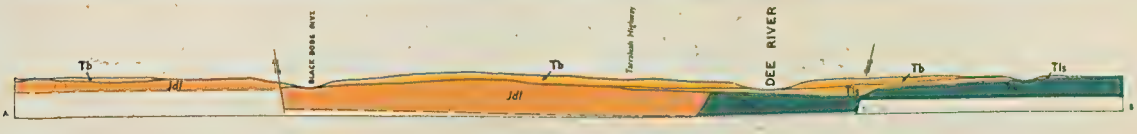
BLACK BOBS

45-77





Quaternary System

Qra ALLUVIUM

Tertiary System

Tls LAKE SEDIMENTS

Tbo BAUXITE

Triassic System

KNOCKLOFTY SANDSTONE AND SHALE

IGNEOUS ROCKS

Jurassic System

Jdl DOLERITE

Tertiary System

Tb BASALT

SCALE

0 2 MILES

0 5,000 10,000 FT.

Key Map Showing Magnetic Variation

Compilation from Aerial Photographs Trigonometric Station Control by courtesy The Hydro-Electric Commission

Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

Mapped and Compiled by J. B. Jennings

September, 1954

FAULT

FAULT — POSITION APPROXIMATE

FAULT INFERRED

FORMATION BOUNDARY

STRIKE AND DIP

DOLERITE BOUNDARIES

DISCORDANT INTRUSIVE BOUNDARIES

VERTICAL JOINT

ROADS

VEHICLE TRACK

TRIG. STATION

BENCH MARK

QUARRY

ANEROID HEIGHT

LANDSLIDE

THE GEOLOGY OF THE BLACK BOBS AREA.

SHEET 45-77.

PHYSIOGRAPHY.

Except for a short distance where it flows over Triassic shales, the Derwent River is in mountain tract in the area and is flowing roughly south-east. Black Bobs Rivulet is similarly mainly in mountain tract. The Dee River is in mountain tract in the north-east corner of the area where it flows over dolerite and sandstone but enters valley tract with meanders and a flood plain on Tertiary lake sediments and basalt. The local valley tract is produced by a resistant dolerite bar downstream.

STRATIGRAPHY.

Cross-bedded quartz sandstones and greenish-yellow shales of Triassic age outcrop in the north-east and near the centre of the square. They are intruded by dykes and sills of dolerite. Bauxite is exposed below basalt below the Liapootah Highway near the northern edge of the square. Tertiary lacustrine sands and clays outcrop in road cuttings in the Liapootah Highway and occur along the valley of the Dee River. Some poorly preserved plant remains are present. Above a silicified gravel there is a thickness of about a thousand feet of basalt in the form of a number of flows with interstratified clays. The basalt probably occupies a former river valley trending south-east.

STRUCTURE.

The area has been broken by faults of two ages. The Jurassic faults trending north-east occur near the junction of Black Bob's Rivulet and the Derwent and about a mile downstream. The Tertiary faults trend N.N.W. across the area.

ECONOMIC GEOLOGY.

Abundant road metal, dolerite or basalt, occurs in the area. Small outcrops of bauxite occur near the northern boundary of the sheet.

REFERENCE.

Jennings, I. B., 1955: The Geology of the Mid-Derwent Area. **Pap. Proc. Roy. Soc. Tas.** Vol. 89.

Geology of the Huon District

By

R. P. Mather

(with 3 maps)

Abstract

The area around Huonville and Glen Huon consists of Permo-Triassic sediments intruded by Jurassic dolerite. Widespread faulting which accompanied the intrusion has controlled the main structures within the area. Fluviatile Tertiary and Quaternary deposits cover the broad valley floors. Those of Tertiary age are associated with basalt.

Introduction

The area dealt with lies within the Huon Municipality of the Southern Region of Tasmania. It is bounded on the east and west by the grid lines 500,000 yards E. and 480,000 yards E., on the north by the grid line 710,000 yards N. and on the south by the grid lines 697,000 yards N. (western half) and 700,000 yards N. (eastern half), on sheet 6 of the four-mile State map of Tasmania.

Use was made of aerial photographs for the construction of the base maps, and for field mapping. A controlled slotted templet layout was used in the former case, and direct tracing on to ethulon over-lay sheets in the latter case. Two sheets of geological maps are published here and the author mapped part of the Franklin area published in 1954 (Ford, 1954).

I am indebted to the staff of the Geology Department of the University of Tasmania for help and advice. Special acknowledgments are due to Professor S. W. Carey who directed the field work, Mr. M. R. Banks for help in the identification of palaeontological specimens and Miss B. Scott for help in the identification of minerals.

Physiography

The area lies within that physiographic unit of Tasmania known as the Southern Highlands (Nye and Blake, 1938). However, extensive erosion by the Huon River system has left the area with two thirds of its surface at less than 1000 feet above sea level, and one third at less than 500 feet above sea level. It is thus in reality part of a region of lower land surface enclosed within the Southern Highlands. This region of lower land surface separates the Wellington block in the north-east from the Hartz block in the south-west. The topography is mature, the original surface having been entirely eroded away. The only peak above 2000 feet is Mount Misery (2279 feet), which is situated in the extreme central north of the area. There is a plateau standing between 1000 feet and

2000 feet in the south-western portion of the area which, like Mt. Misery and an elevated region of hilly and mountainous country between Huonville and Pelverata, gives way to less elevated surfaces. There less elevated surfaces. composed mainly of the broad valleys of the Huon and Mountain Rivers, stand at less than 500 feet and are covered in part by river terrace and more recent alluvial material.

During the Lower Tertiary, a peneplain developed in the Late Mesozoic (Hills and Carey, 1949), was subjected to widespread block faulting, which gave rise among other physiographic units to the Southern Highlands. It was this Tertiary faulting, or " Plateau Uplift " as Lewis (1945) called it, which initiated the present erosional cycle of the Huon River System. However although the present relief of this area was the result of this regional faulting throughout Tasmania, no definite Tertiary faults have been recognised within the area. The next stage was the deposition of fluviatile material on the broad valley floors, and the later development of river terraces.

For its entire length within the area, the course of the Huon River lies in valley tract, but estuarine conditions prevail south of Huonville. There is some evidence that the straight portion of the Huon River west of Ranelagh has been controlled by a fault which parallels this section of the stream. Its course at Ranelagh has been changed to the south by a basalt flow, and at Ironstone Creek half a mile downstream from Huonville, dolerite has been responsible for a swing to the south-west. The dolerite is more resistant to erosion than the softer sedimentary rocks, and consequently has produced temporary irregularities in the stream profile in the higher reaches of the Huon River.

The tributaries of the Huon River are short and youthful, and are in mountain tract for the greater part of their length. Waterfalls and rapids are not uncommon.

The Mountain River south of Lucaston is in plains tract, where it has formed incised meanders in the fluviatile deposits covering its broad valley floor. The headwaters of its tributaries, like those of the Huon River are in mountain tract. However they pass into valley and sometimes plains tract before joining the Mountain River.

In places, particularly along the Mountain River valley, the fluviatile deposits can be recognised as constituting river terraces. Owing to recent erosion and cultivation, it is difficult to trace more than one terrace margin with any certainty. Aneroid measurements disclosed a uniform fall in the top of the terrace material of 250 feet from the northern boundary on the Mountain River to the southern boundary on the Huon River. The top levels of the terrace material on both Judds Creek and the Huon River at the western boundary of the area are approximately equal to the top level already mentioned for the Mountain River north of Grove.

On proceeding past the Grove turn-off towards Huonville, terraces can be seen on both sides of the road. They rise 20 feet above the plain located between Blackfish and Fourteen Turn Creeks. These two creeks are entrenched about 10 feet below the general level of this plain. Thus in this vicinity, the stream beds are 30 feet below the top of the terrace.

About a mile south of the junction of Blackfish Creek, the Mountain River stands at 90 feet below the terrace level, and is still entrenched about

10 feet below its present banks. The terrace level here is 80 feet below the level at Grove and 40 feet below the level shown on the Huon Highway to the east.

Just south of Huonville, terrace material is 80 feet above the Huon River, and at Franklin, 50 feet. West of Judbury on the Huon River, terrace material occurs up to 100 feet above the river.

Although they cannot be traced with certainty, other terrace levels exist within the area. This indicates that the relative uplift responsible for the terrace formation was not a single event. These terrace levels may be an expression of the fluctuating sea level caused by the Pleistocene glaciation.

The most recent relative uplift of 10-15 feet reported from other localities is shown by the entrenchment of the streams by about 10 feet.

Stratigraphy

The following stratigraphic units are present:—

	Thickness in feet
QUATERNARY SYSTEM:	
Fluviatile gravels, &c.	
TERTIARY SYSTEM:	
Basalts	
Fluviatile gravels, &c.	
TRIASSIC SYSTEM:	
Feldspathic Sandstone	?
Knocklofty Sandstone and Shales	900+
PERMIAN SYSTEM:	
Cygnet Coal Measures	?
Ferntree Mudstone	470-600
Woodbridge Glacial Formation	200+
Grange Mudstone	?

Permian System

The Permian rocks of the area are mainly confined to the Ferntree Mudstone and Woodbridge Glacial Formations. However, there are several occurrences of Grange Mudstone.

The base of this system is not exposed. The lowest Permian rocks are represented by the Grange and Woodbridge Mudstones where they outcrop above Cainozoic gravels.

This System is overlain by the Knocklofty Sandstone and Shale Formation which is well developed throughout the area.

Grange Mudstone

Because of the absence of the development of a basal conglomerate member of the Woodbridge Glacial Formation, it is not always possible to identify the Grange Mudstone.

Although in some cases lithological and palaeontological characters allow a distinction to be made, the Grange Mudstone does not constitute a mappable unit within the area and has not been shown on a map as a formation distinct from the Woodbridge Glacial Formation. However the localities where it was recognised are indicated. Mudstones stratigraphically equivalent to the Grange Mudstone elsewhere may be more widespread in extent than indicated.

A few feet of a very fossiliferous, partly calcareous, grey shaly mudstone is exposed in the river bank near the old wharf at Ranelagh. It is unconformably overlain by Tertiary fluviatile deposits, and to the south is faulted against Knocklofty Sandstone. Its direct relation to other Permian rocks is obscured, but from its position it appears to be the lowest horizon exposed within the area.

The fossils it contains are generally large and sturdy, and quite often the original carbonate material of their structure is still preserved. The main fossils are spiriferids, productids, bryozoans including *Fenestella* sp. and various species of aviculopectinids.

A soft, richly fossiliferous, massive, silty mudstone dominantly white in colour is exposed in a road cutting at 489500E—705250N, west of Ranelagh. The white colour gives way to yellow and orange in irregular patches, due in part to weathering. There are a few grains between 0·4 mm. and 0·8 mm. set in an even groundmass of smaller grains. The dominant mineral is quartz. The fossils include *Fenestella* sp., *Polypora* sp., spiriferids and a portion of an aviculopectenid.

This exposure is 390 feet stratigraphically below the top of the Woodbridge Formation, exposed to the west.

In another road cutting at 489770E—705870N, a soft, creamy yellow, fine grained, richly fossiliferous mudstone is exposed across a fault from the occurrence mentioned above. The fossils include *Fenestella* sp. and some pelecypods.

This mudstone horizon is 280 feet stratigraphically below the top of the Woodbridge Formation exposed up the hill to the north-east. It is overlain by silty and sandy mudstones associated with fine conglomerates 80 feet above the mudstone. Scattered fossils and quartzite erratics up to 5 cm. in diameter are present.

This fine conglomeratic material, not observed elsewhere, may be the stratigraphic equivalent of the basal conglomerate of the Woodbridge Formation. This is the only indication of the upper limit of the Grange Mudstone observed within the area.

Rock fragments resembling Grange Mudstone were found loose at Lucaston, and on the southern boundary of the area just east of the Huon River. These localities are adjacent to hills on which the Woodbridge Glacial Formation is exposed.

Woodbridge Glacial Formation

This formation which is at least 200 feet thick lies conformably between the Risdon Sandstone member of the Ferntree Mudstone above, and the Grange Mudstone below. The uncertain nature of the lower boundary has been discussed. The upper boundary is well defined throughout the area.

The lower beds of the Woodbridge Glacial Formation exposed in the area are composed of a white and grey silty mudstone containing glacial erratics up to 5 cm. in diameter, composed mainly of quartzite, although other material including black slate has been observed. Some of the erratics are in their second cycle of sedimentation. The Owen Conglomerate appears to have been one of the parent rock types. Bryozoan, brachiopod and mollusc fossils are present.

This silty mudstone is associated in part with a variable sandstone composed of angular quartz grains, which occurs about 100 feet stratigraphically below the top of the Woodbridge Glacial Formation. This sandstone is exposed on the southern boundary of the area just east of the Huon River, and in the section shown above locality 489770E—705870N, west of Ranelagh.

The top 100 feet of the Woodbridge Glacial Formation is very often composed of a mottled red, yellow and grey silty mudstone containing scattered marine fossils and fewer glacial erratics than lower beds. The fossils are mainly brachiopods including spiriferids and productids and molluscs including aviculopectinids. Bryozoans appear to be very sparse.

One specimen of massive silty mudstone from about 30 feet below the top of the Woodbridge Formation from locality 488930E—707400N, contains angular grains of quartz up to 3 mm., set in a matrix of grains less than 0·8 mm. The degree of sorting for the finer grains (less than 0·4 mm.) is poorer than for the Grange Mudstone. Also the grains in the 0·4-0·8 mm. range are more angular than the finer ones. With normal erosion and deposition by water this is not the case.

There are some aggregates up to 0·8 mm. which contain equidimensional quartz particles of about 0·07 mm. Fine micaceous material and a few grains of orthoclase are present. Silica is the dominant cement, but some limonitic cement is present.

Ferntree Mudstone

This formation lies between the Woodbridge Glacial Formation below and the Knocklofty Sandstone and Shale Formation above.

The basal member of this formation is the Risdon Sandstone, a 20 feet thick marker horizon of great value in field mapping. It is a very variable member showing all gradations from a conglomerate with quartz pebbles up to 3 cm. in diameter set in a matrix of angular quartz and feldspar, to a sandstone with feldspar. The finer phases which, in certain instances resemble Triassic Sandstone, are composed mainly of grains between 0·5 mm. and 1 mm. The cement is of both ferruginous and siliceous types and fine micaceous material, interstitial quartz, and some plagioclase are present. In the coarser phases some of the quartz grains are blue-grey in colour and others show a secondary growth of silica around their margins. The larger particles in the coarser phases are sub-rounded to angular. At locality 490040E—706080N, west of Ranelagh, the coarser phases show a lower percentage of matrix, and the finer phases are cross-bedded.

Overlying the Risdon Sandstone is an unfossiliferous hard grey and white mottled mudstone with interbedded black shaly bands up to several feet thick. Glacial erratics occur scattered throughout, but are more abundant towards the base. However, they are not nearly as plentiful as in the Woodbridge Glacial Formation and are usually less than 3 cm. in diameter.

Although most of this formation is composed of a mudstone with small glacial erratics, there are siltstone phases which resemble some of the unfossiliferous parts of the Woodbridge Glacial Formation. A specimen of typical mudstone from near the top of the formation showed

the grains to be predominantly about 0·08 mm. in size with a few scattered ones up to 0·8 mm. The grainsize is more even than in the Woodbridge Mudstones. The cement is mainly siliceous and there are a few scattered feldspar grains. The stratigraphic thickness of the Ferntree Mudstone has been measured near Judbury where it is 470 feet, between Judbury and Ranelagh where it is 500 feet, and north of Ranelagh where it is not more than 600 feet. In the north-west of the area there are 555 feet exposed above fluviatile deposits, but the Risdon Sandstone is not exposed.

Black shaly bands are shown alternating with a massive, hard grey-white mudstone for 20 feet, at a point 120 feet above the base of the Ferntree Mudstone in a cliff face at locality 491550E—707560N, north of Ranelagh. These black shaly bands are often found in the Ferntree Mudstone where it is exposed at the margins of terraces underlying Cainozoic gravels along the valley of the Mountain River near Grove.

Cygnet Coal Measures

These beds are not exposed within the area. However, in the vicinity of locality 489500E—699000N, south-west of Huonville, carbonaceous shale is exposed below water-level in a flooded adit driven in Knocklofty Sandstone. Near the mouth of this adit there are fragments of carbonaceous shale on the dump of a shaft which has been filled in. This may indicate that the Knocklofty Sandstone in this vicinity overlies carbonaceous shale which is either part of the Ferntree Mudstone or is equivalent to the Cygnet Coal Measures. This Formation was not observed elsewhere within the area.

Triassic System

The Permian-Triassic boundary has not been observed to outcrop sufficiently clearly within the area to allow a close examination. However in adjacent areas to the south slight disconformity has been established (Hale, 1953).

The Triassic System is mainly represented by the Knocklofty Sandstone and Shale Formation. There are limited occurrences of Feldspathic Sandstone. Due to erosion and the intrusion of dolerite, the upper limits of this system cannot be seen within the area.

Knocklofty Sandstone and Shale

The basal member of this formation is a variable conglomerate composed mainly of sub-angular to sub-rounded quartz particles up to 1 cm. in diameter set in a matrix of sand grade quartz with some feldspar. The material of the matrix is sub-angular. Both siliceous and ferruginous cements are present, the former being dominant. There are not many feldspar grains larger than 2 mm. The weathered surfaces show no feldspar, which gives the rock the appearance of being entirely siliceous. With the removal of the feldspar by weathering, the rock tends to disintegrate causing deposits of sand to accumulate at the base of this formation. Both the larger pebbles and nodular structures associated with iron oxides stand out from the rock when it weathers.

The coarsest phase appears to be about 50 feet above the base. This basal member passes upwards into a light coloured, even grained sandstone (0·1 mm.-0·3 mm.) composed dominantly of sub-angular to sub-

rounded quartz fragments. The finer grains are more angular than the coarser ones. The feldspar found in the lower phases is almost completely absent from sandstone immediately overlying it.

Cross-bedding is found right through this overlying member and is present to a lesser extent in the top beds of the basal member. The general direction of deposition as indicated by cross-bedding is from the west.

The massive sandstones which overlie the basal member pass up into a member composed of interbedded sandstone and shale members. These shaly bands have been observed 80 feet stratigraphically above the base of the formation at locality 496900E—705900N, between Grove and Pelverata. These shales prove to be much less resistant to weathering than the interbedded sandstone, and as a result are often obscured. Thin shaly bands can be missed in a cliff face. However, differential weathering usually indicates the presence of shaly members.

Throughout the Knocklofty Formation there are developed curious slump structures which appear to be contemporaneous with sedimentation, or to have occurred soon after sedimentation but before complete consolidation took place. They are usually associated with cross-bedding and occur within the more massive sandstone members.

Clay pellet conglomerate horizons occur at various levels, but no stratigraphic value has been established for them. These clay pellets are up to 3 cm. in diameter and are set in an even grained sandstone matrix.

Mica with muscovite predominating, occurs throughout the formation, but is best developed within the shaly bands. Here it is often associated with graphite and dendrites. The mica and graphite are probably primary, the formation not having suffered conditions capable of producing these minerals in a secondary form.

Determinations on the sandstones from this formation show their heavy mineral content to be very low, the highest value obtained being 0·22 per cent. Minerals include ilmenite, haematite, limonite (as staining on quartz grains), tourmaline, zircon, topaz, rutile and garnet, which suggest acid igneous and metamorphic rocks as a source material for these sediments.

Grain size analyses, and the presence of cross-bedding indicate that these sediments have been reworked. However, there has not been much modification of the shape of the grains which suggests that this reworking and the distance of transport from the source has not been great. This is supported by the presence of primary mica.

There are 900 feet of this formation exposed south of Glen Huon. However, the top has not been observed so a total thickness cannot be given.

Feldspathic Sandstone

This rock type which conformably overlies the Knocklofty Sandstone and Shale Formation has only been observed at two localities within the area.

It is an even grained sandstone composed of quartz and feldspar grains (0·1-0·3 mm.) which vary in shape from well rounded to sub-angular. Ilmenite, zircon and topaz grains are present as heavy minerals.

At 499500E—702570N, north of Pelverata, Feldspathic Sandstone is exposed in a creek bank. It is associated with coal. The association of this coal with alluvial material suggests that the coal is not *in situ*.

The other occurrence of Feldspathic Sandstone is completely surrounded by dolerite which obscures its relationship to other sedimentary rock types.

Cainozoic Fluviatile Deposits

The valleys of the Huon and Mountain Rivers contain both Tertiary and Quaternary fluvial deposits. These deposits are semi-consolidated, ill-sorted sedimentary material which shows very little evidence of bedding and is composed mainly of sub-rounded quartzite or dolerite pebbles and cobbles set in a matrix of sand and silt. The size of the quartzite cobbles varies up to 15 cm. and of the dolerite up to 40 cm. The sand and silt grade particles of the matrix tend to be sub-angular. In addition to quartzite and dolerite cobbles, other rock fragments are common.

Lewis (1935) on evidence in other parts of Tasmania distinguishes the deposits containing quartzite material from those containing predominantly dolerite and mudstone particles. He considers the former to be of Tertiary age and the latter of Quaternary age.

At locality 492100E—705100N, near the old wharf at Ranelagh, fluviatile deposits composed mainly of ill-sorted quartzite pebbles in a matrix of sand and silt underlie basalt. These deposits unconformably overlie Permian mudstone, and are considered to be of Tertiary age. Lewis (1935, p. 81) has referred to this exposure.

Fluviatile deposits composed predominantly of doleritic material have been observed to lie above the basalt. At locality 494900E—707300N, basalt is overlain by fluviatile deposits containing quartzite particles.

In places these fluviatile deposits can be recognised as constituting river terraces. Owing to recent erosion and cultivation it is difficult to trace more than one terrace margin with any certainty.

Throughout the area there are occurrences of Recent alluvium situated at not more than 10-15 feet above the present stream levels.

Igneous Rocks

Jurassic Dolerite

This is the dominant igneous rock type found within the area. It occurs as intrusive masses within the Permo-Triassic sediments, where it has formed sills and transgressive bodies with associated dykes.

A partly transgressive sill occurs within the Knocklofty Sandstone and Shale Formation, the base level varying from 220 feet to 900 feet above the lower boundary of this formation. It has not been possible to determine the thickness of this body, but at least several hundred feet of it are exposed within the area.

There are smaller secondary sill-like bodies up to 120 feet thick which occur at or near the Permo-Triassic boundary. Some of these may be outliers separated from the main overlying sill by erosion.

The transgressive bodies are associated with faulting which accompanied the dolerite intrusion. Often where the dolerite has come into contact with sediments, these show signs of metamorphism. Also in many localities chilled margins of very fine dolerite have been observed.

The dolerite is the normal type, containing labradorite laths up to 1 mm. and augite crystals up to 2 mm.

Tertiary Basalt

Basalt was only observed at two localities and in each case is overlain by fluviatile deposits. At locality 494900E—707300N, its base is obscured, but at locality 492100E—705100N, near Ranelagh it conformably overlies fluviatile deposits. The flow at this locality is from 10-15 feet thick.

The basalt is vesicular in part, the vesicles being up to 4 mm. At the first locality mentioned, the vesicles show slight elongation due to flow and are parallel to the present direction of the river where they occur. Pillows can be seen towards the base of the flow.

Microscopic examination shows labradorite up to 0·1 mm. and olivine crystals up to 0·8 mm.

A Pliocene age has been suggested for other basalts in Tasmania (Hills and Carey, 1949, p. 36) so in the absence of contrary evidence this basalt is regarded as Pliocene in age.

Structural Geology

The structure of this area dates from the Jurassic. When the dolerite was intruded through the older basement rocks into the Permo-Triassic sediments, it rose vertically as dykes and inclined transgressive bodies, as well as spreading laterally as sills at favourable levels. This resulted in a differential vertical movement of gigantic blocks of sediment. To allow this movement, widespread concomitant faulting occurred.

In most cases the highlands are capped with dolerite sills. However, the highest peak in the area, Mount Misery (2279 feet), is composed of Knocklofty Sandstone.

In the western part of the area in the vicinities of localities 480000E—701000N, 482800E—703000N, and west of Dora Creek, are shown the remnants of a dolerite sill which stands approximately 250 feet above the base of the Knocklofty Sandstone.

Faults concomitant with the dolerite intrusion break across this region with a north-south trend. It is through these breaks that the dolerite has fed the sills above. The transgressive dolerite masses situated between Dora and Judds Creeks, and south of Dickenson Creek mark the positions of the main breaks. The presence of metamorphosed sediment and fine grained dolerite along the margins of these breaks support their concomitant nature.

The highlands east of Judbury are capped by a partly transgressive dolerite sill which stands at 220 feet above the Permo-Triassic boundary. Further to the east its height above this boundary increases to 600 feet. The dolerite at locality 486000E—709300N, is a transgressive body fed from this sill.

South of Glen Huon the highlands are capped by a dolerite sill which stands 900 feet above the Permo-Triassic boundary and extends east to Huonville. To the south this sill passes into longer transgressive masses of dolerite from which it has probably been fed.

There is a persistent Jurassic fault trending south-west from Grove. It marks the boundary of the large dolerite mass on its south-east with the Permian and Triassic sediments which skirt the eastern side of the broad valley of the Mountain River. The eastern margin of this dolerite mass is defined by another fault which trends north-east from Pelverata.

The lowest block in the area is about a mile north of Pelverata. Feldspathic Sandstone is exposed in stream banks where it underlies dolerite. This dolerite capped block of Feldspathic Sandstone is faulted against Knocklofty Sandstone to the south. The southern and western margins of this block and the western margin of the Feldspathic Sandstone block are bounded by dolerite.

There is an inlier of dolerite in the Knocklofty Sandstone east of Pelverata. It has an intrusive contact with the surrounding sediment and is probably continuous with the dolerite to the south at a small depth below the surface.

The structure in the vicinity of locality 497500E—705000N, is shown by section A-B. The sandstone block shown in the south-east of the section appears to be an isolated " floating " block.

In the north-east of the area, is a sedimentary block bounded on the north, west and south by dolerite. The dolerite is well jointed to the west; the joints strike at 110° and dip at 60° to the north. Although the dolerite tends to be fine grained at the contact with the sandstone to the east where it is exposed in a road cutting at locality 499130E—709130N, the sandstone appears to be free from metamorphism. This fault has been regarded as concomitant with the dolerite intrusion, but the possibility of its being a Tertiary fault should not be overlooked, although no evidence of this was found to the south-east.

To the west towards Grove, Knocklofty Sandstone is exposed at least 200 feet below the base of the sandstone in the sedimentary block to the east. South of Grove, Risdon Sandstone is exposed 250 feet below this base. The transgressive nature of the igneous contact of the dolerite with the Ferntree Mudstone is shown in a quarry at locality 497870E—709090N.

Repetition of the Risdon Sandstone south of Grove suggests one or two strike faults with small throws of about 50 feet.

At various localities including 496260E—709000N, 495700E—707000N, and 495300E—706300N, the Risdon Sandstone is exposed below the fluviatile deposits of the Mountain River. This indicates that the rock underlying this terrace material is composed of the base of the Ferntree Mudstone and the top of the Woodbridge Glacial Formation. The under-

lying sediments were examined at the terrace margins, but it is difficult to determine the structure of this blanketed region.

The rocks on the north and south of the Huon River west of Glen Huon appear to rank, but on proceeding to the east those to the south are found to be relatively lower, which suggests an east-west fault along the Huon River. This is supported by evidence near the old wharf at Ranelagh where fossiliferous Grange Mudstone strikes into Knocklofty Sandstone. This indicates a vertical displacement of at least 700 feet. Although this fault is covered by alluvial material for the greater part of its length, its western extremity appears to be associated with a Jurassic fault at locality 483300E—702550N. Just east of this point there is evidence for a throw of 200 feet as shown by the relative positions of the Permo-Triassic boundary. The extension of this fault east of Ranelagh is in doubt, but it does not appear to emerge on the eastern side of the Mountain River Valley.

There appears to be a fault down the Mountain River Valley which would account for this, and also the fact that the Ferntree Mudstone east of Lucaston does not rank with the Woodbridge Glacial Formation to the west. It would also account for the discrepancy in levels of the sandstones near Huonville, where the Knocklofty Sandstone and Shale exposed in the west bank of the Huon River are stratigraphically above the sandstone exposed about a mile to the east. The observed dips fail to account for this.

In the central north of the area, there are several sandstone-sandstone faults associated with faults concomitant with the dolerite intrusion which are responsible for the elevated position of the Mount Misery block. At the base of the eastern scarp of Mount Misery, material resembling the base of the Knocklofty Sandstone is exposed against sandstone which is at least 200 feet stratigraphically above the Triassic base. A few isolated pieces of very fine grained dolerite were found in the soil. Dolerite is exposed both to the north and south of this locality.

In the vicinity of locality 487500E—702500N, is a down faulted block with a displacement of at least 200 feet at its northern extremity.

LOCALITY INDEX

	Internat. Grid Reference K/55 Quadrangle		S.Lat.	E.Long.
Blackfish Creek	Hobart	82	43° 00′	147° 6′
Dickenson Creek	Picton	87	43° 2′	146° 51′
Dora Creek	Styx	81	42° 59′	146° 51′
Fourteen Turn Creek	Hobart	82	42° 59′	147° 7′
Franklin	Kingborough	88	43° 5′	147° 1′
Glen Huon	Picton	87	43° 2′	146° 57′
Grove	Hobart	82	42° 59′	147° 5′
Huon River	Kingborough	88	43° 2′	147° 4′
Huonville	Kingborough	88	43° 2′	147° 4′
Ironstone Creek	Kingborough	88	43° 2′	147° 5′
Judbury	Styx	81	43° 00′	146° 56′
Judds Creek	Styx	81	42° 59′	146° 52′
Lucaston	Hobart	82	42° 59′	147° 3′
Mountain River	Hobart	82	42° 59′	147° 4′
Mt. Misery	Hobart	82	42° 59′	147° 00′
Pelverata	Kingborough	88	43° 3′	147° 7′
Ranelagh	Picton	87	43° 1′	147° 2′

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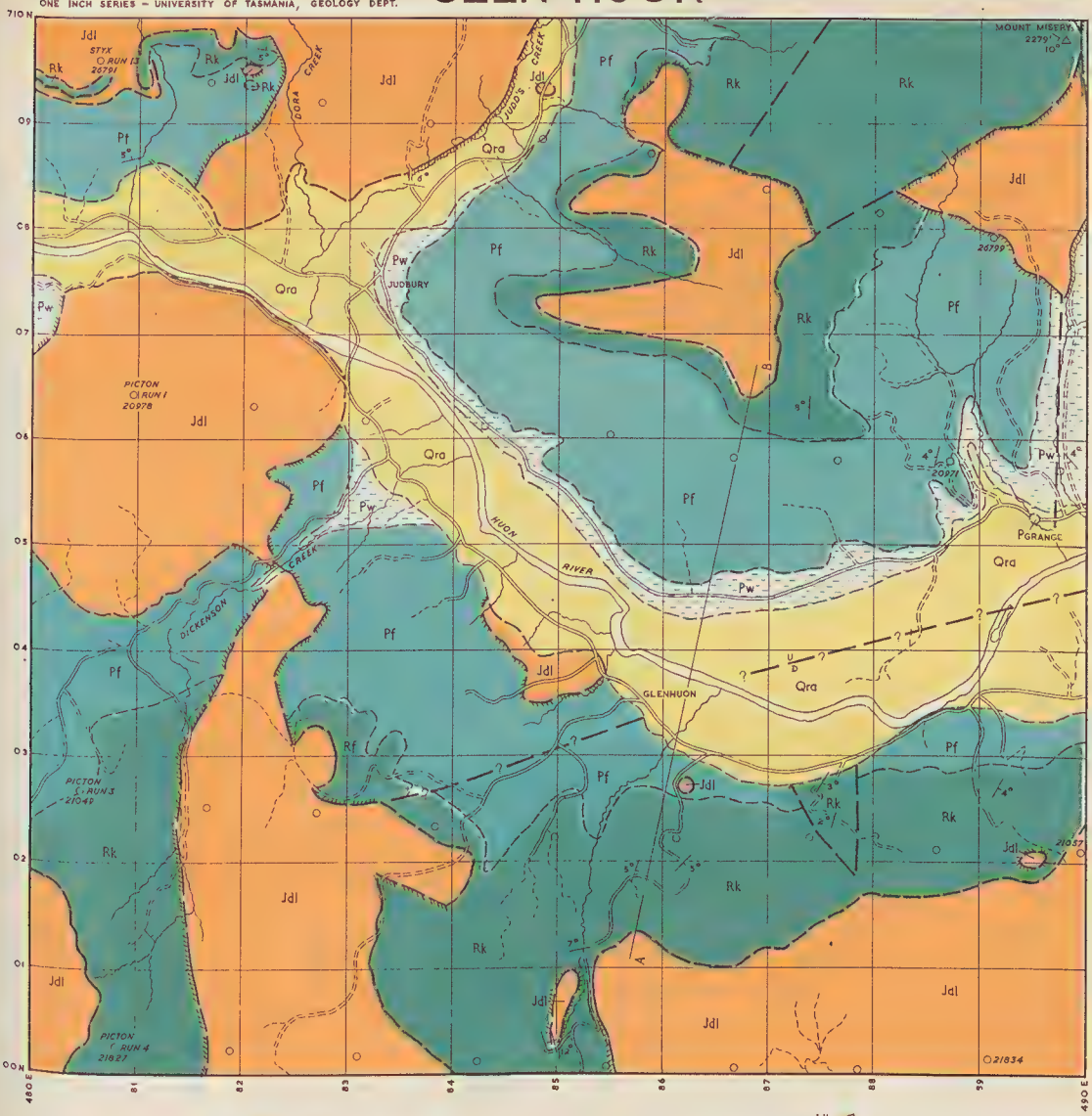
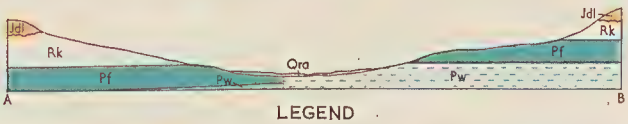
GEOLOGY OF TASMANIA
ONE INCH SERIES – UNIVERSITY OF TASMANIA, GEOLOGY DEPT.

GLEN HUON

4870





LEGEND

- FAULT WITH DOWNTHROWN SIDE INDICATED
- FAULT – POSITION APPROXIMATE
- FAULT INFERRED
- FORMATION BOUNDARY

Dolerite Boundaries

- CONCORDANT SILL
- DISCORDANT INTRUSIVE BOUNDARY
- STRIKE AND DIP
- ROAD
- VEHICULAR TRACK
- FOOT TRACK
- PHOTO CENTRE
- TRIGONOMETRICAL STATION

Cainozoic Rocks

- Qra ALLUVIUM AND SUB-BASALTIC GRAVELS

Triassic System

- Rk KNOCKLOFTY SANDSTONE AND SHALE

Permian System

- Pf FERNTREE MUDSTONE
- Pw WOODBRIDGE GLACIAL FORMATION

IGNEOUS ROCKS

Jurassic System

- Jdl DOLERITE

— SCALE —

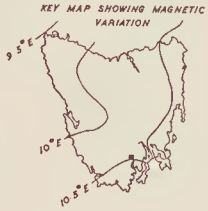
0 1 2 3 4 5,000 10,000 FEET

0 1 2 MILES

MAPPED AND COMPILED BY
R.P. MATHER JANUARY, 1952.

Compilation from Aerial Photographs.
Trigonometric Station Control by courtesy Lands and Surveys Department.
Origin of co-ordinates 400,000 yds West and 1,800,000 yds South of True Origin of Zone 7.

KEY MAP SHOWING MAGNETIC VARIATION



THE GEOLOGY OF GLEN HUON.

SHEET 48-70.

PHYSIOGRAPHY.

The Huon River is in valley tract throughout this sheet and its various tributaries mainly in mountain tract. The course of the Huon below Glen Huon is probably fault controlled. Terraces on Judd's Creek and the Huon above Judbury are at a level of about 250 feet above sea level, and the Huon is entrenched about 100 feet in these terraces.

STRATIGRAPHY.

The oldest rocks exposed belong to the Grange Mudstone of the Permian System and are overlain by the Woodbridge Glacial Formation which underlies the Ferntree Mudstone which is only 490 feet thick at Judbury, although it increases in thickness to the north-east. South of Glen Huon over 900 feet of Knocklofty Sandstone and Shale of the Triassic System overlie the Ferntree Mudstone. Dolerite occurs in this area as a sill transgressing from just above the base of the Knocklofty Sandstone and Shale north of the river to as much as 900 feet above the base to the south of the river.

STRUCTURE.

The main structure is that of horizontal or subhorizontal beds injected by dolerite along steep contacts trending somewhat east of north along Dickenson's and Judd's Creeks. These beds are displaced by a fault trending north of east along the Huon River but this fault apparently does not displace the dolerite.

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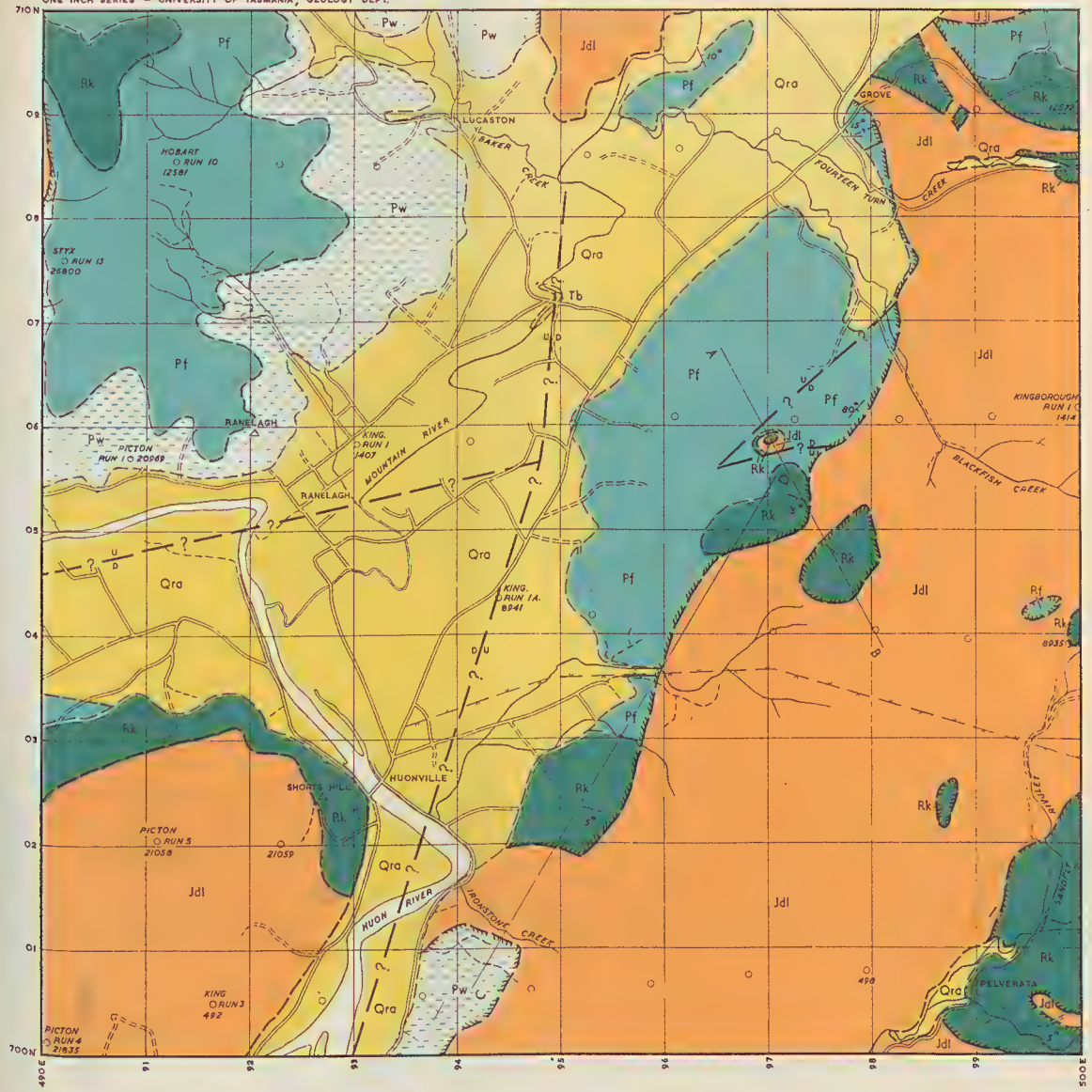
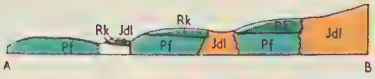
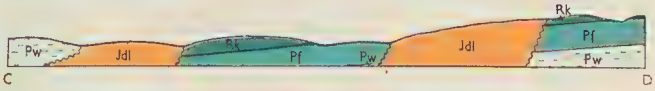
HUONVILLE







LEGEND

- FAULT WITH DOWNTHROWN SIDE INDICATED
- FAULT – POSITION APPROXIMATE
- FAULT INFERRED
- FORMATION BOUNDARY

Dolerite Boundaries

- CONCORDANT SILL
- DISCORDANT INTRUSIVE BOUNDARY
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- ROAD
- VEHICULAR TRACK
- FOOT TRACK
- TRANSMISSION LINE
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Cainozoic Rocks

- Qra ALLUVIUM AND SUB-BASALTIC GRAVELS

Triassic System

- Rf FELDSPATHIC SANDSTONE
- Rk KNOCKLOFTY SANDSTONE AND SHALE

Permian System

- Pf FERNTREE MUDSTONE
- Pw WOODBRIDGE GLACIAL FORMATION

IGNEOUS ROCKS

Tertiary System

- Tb BASALT

Jurassic System

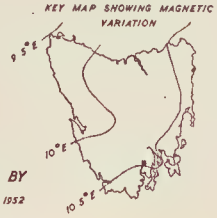
- Jdl DOLERITE

— SCALE —

0 1 2 MILES
0 1 2 3 4 5,000 10,000 FEET

Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Lands and Surveys Department. Origin of co-ordinates 400,000 yds West and 1,800,000 yds South of True Origin of Zone 7.

KEY MAP SHOWING MAGNETIC VARIATION



MAPPED AND COMPILED BY R.P. MATHER JANUARY, 1952

THE GEOLOGY OF HUONVILLE.

SHEET 49-70.

PHYSIOGRAPHY.

The Huon River in this sheet is in valley tract with estuarine deltaic features below Huonville. The Mountain River, chief tributary of the Huon, is in plains tract south of Lucaston. River terraces fall uniformly in height, from about 250 feet above sea level at Grove to 50 feet at Franklin and the Mountain River is entrenched by as much as 90 feet and the Huon by 80 feet. Other terraces occur. Streams are generally entrenched by 10 feet in the lowest terraces. Tributaries of the Huon and Mountain Rivers are mainly in mountain tract. The Huon flows between the highlands of the Wellington block to the north-east and those of the Hartz block to the south-west.

STRATIGRAPHY.

Permian rocks are the oldest exposed in the area with about 200 feet of Woodbridge Glacial Formation occurring north-west of Ranelagh and overlain by from 470 to 600 feet of Ferntree Mudstone. Triassic rocks, Knocklofty Sandstone and Shale, occur on the heights west of Lucaston, near Grove, Pelverata and along the south bank of the Huon above Huonville. Isolated outcrops of Feldspathic Sandstone occur north of Pelverata. Cainozoic river deposits occupy the valley floors. Dolerite occurs mainly as a slightly transgressive sill in the Knocklofty Sandstone and Shale and as a wide dyke east of Huonville. Basalt is exposed in the bed of the Mountain River a mile and a half above Ranelagh and the base shows pillow structure.

STRUCTURE.

The main structure is a Jurassic fault trending south-west from Grove with a roughly parallel fault at Pelverata. There is probably another fault trending just east of north through Huonville. To the west of this fault the Permian and Triassic rocks are almost horizontal. A fault striking just south of west probably underlies the Huon River west of Huonville.

POINTS OF SPECIAL INTEREST.

Tertiary basalt with pillows 492100 E—705100 N
River terraces: main road near Fourteen Turn Ck.
Grange Mudstone (?): old wharf, Ranelagh.
Knocklofty Sandstone and Shale: Scott's Hill.

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Permian Varves from Wynyard, Tasmania

By

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J. L. Loveday
Soils Division, C.S.I.R.O.,

and

D. Ll. Scott

(with 3 plates and 6 text figures)

Abstract

Thinly laminated to very thinly bedded varved mudstones are associated with tillite and thinly cross-laminated sandstone in the Wynyard Tillite in the Wynyard area, north-west Tasmania. Many of the varves are highly coloured. Simple drainage and composite varves are present. The varves show slump structures and ripple marking. Sedimentary structures, textures and the types of erratics indicate derivation from the south or south-west. Oil shale, probably of Upper Artinskian age, occurs within fifty feet of the top of the tillite and is conformable with it. At least three advances and retreats of the Permian ice sheet are indicated. The Wynyard Tillite is defined in terms of the Australian Code of Stratigraphic Nomenclature.

Introduction

The Wynyard Tillite was first recorded by Stephens (1869) who, although recognising it as a glacial deposit, did not comment on its age or formally name it. It was called the Wynyard Formation by Montgomery (1896) but it is mainly known through the detailed description by David (1907). Although earlier authors describe rocks in the formation which could be varves, they did not recognise them as such. The present authors have recorded their discovery in a short preliminary note (Banks, Loveday and Scott, 1954).

During a survey by the Soils Division, C.S.I.R.O., in the summer of 1953-4, Messrs. Loveday and Scott first noticed these rocks and described them to the other author who suggested they might be varves. On a subsequent trip to the area, closer observations were made and specimens collected for examination. All the facts confirm the earlier suggestion that these rocks are varves.

Colours were determined by the use of the Rock-colour Chart (Goddard et al, 1948) and the formulae which accompany colours in the text refer to this notation. Bedding and cross-bedding terminology is that of McKee and Weir (1953). The authors wish to acknowledge, with many thanks, the assistance of Mr. G. E. A. Hale, of the Tasmanian Museum, in determining the clay minerals.

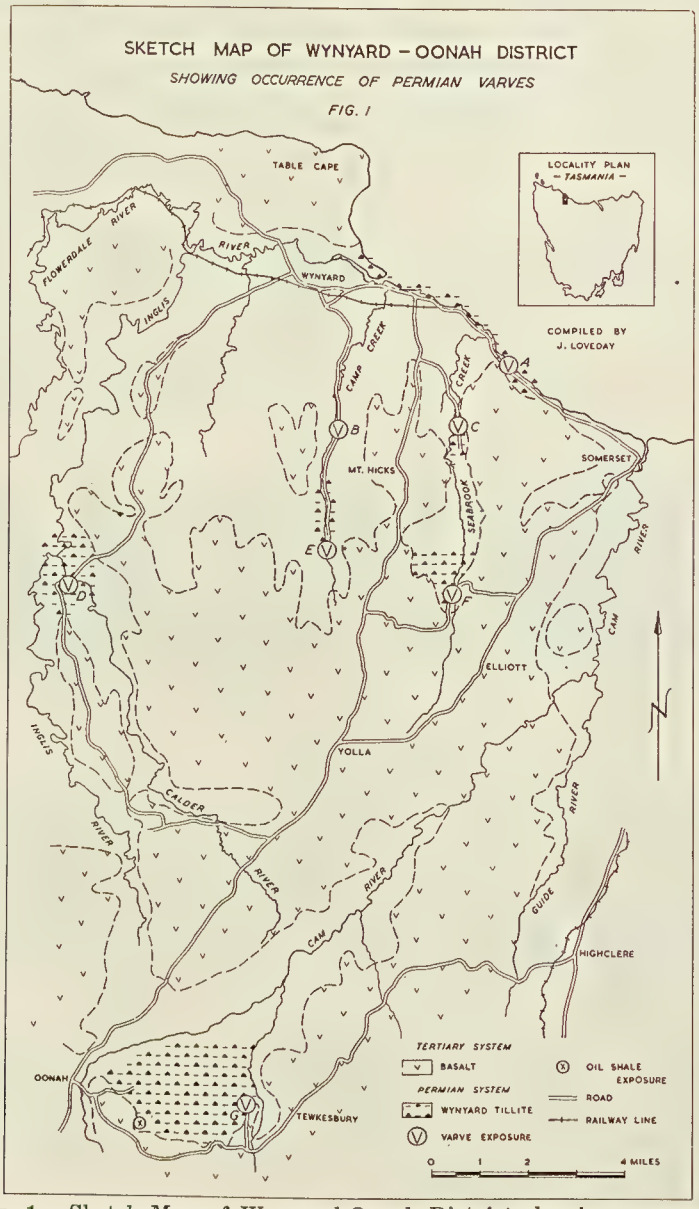

FIG. 1.—Sketch Map of Wynyard-Oonah District showing occurrence of Permian Varves.

Wynyard Tillite

The Wynyard Tillite is defined as that formation of tillite, with subordinate sandstones and varved mudstones, resting unconformably on Devonian or older rocks and overlain conformably by sandstones and siltstones, as exposed in the creek bed east of Oonah Post Office. The tillite is 1220 ft. thick according to David (1907) and is probably Sakmarian and Artinskian in age. The type area is the Wynyard district, but no uninterrupted section can be quoted.

This formation has received various names in the past, as shown in the following list:—

Wynyard Formation:
Montgomery, 1896
Waller, 1902
Twelvetrees, 1905
Noetling, 1909
Wynyard Glacial Formation:
Hills and Carey, 1949
Banks, Loveday and Scott, 1954
Wynyard Glacial Stage: Voisey, 1938
Wynyard Mudstone Conglomerate: Hills, 1913
non Wynyard Stage: Nye and Lewis, 1928

The geographic name was first applied by Montgomery (1896), but it had been recognized as a tillite by Stephens (1869). Montgomery gave its age as Permo-Carboniferous and has been followed in this by Kitson (1902), Twelvetrees (1905), David (1907) and most other authors. However, Noetling (1909) incorrectly considered it to be Pleistocene. The name tillite is here used in preference to glacial formation as the formation is dominantly tillitic. The tillite occurs at least as far south as the Hellyer Gorge (Lewis, 1929) and as far south-west as the junction of the Arthur and Keith Rivers. It is commonly exposed in gullies, cut through the basalt south of Wynyard. Details of the lithology and age of this formation are discussed by David (1907) and the present authors (see later).

The varved mudstones occur on several horizons within the tillite formation and may eventually prove to be members occupying consistent stratigraphic horizons. The geographic distribution of the varved mudstones is shown in the accompanying map (fig. 1) and the occurrences will be discussed in the order used on the map.

Stratigraphy and Field Occurrence

At Doctors Rock (A in fig. 1)* two miles east of Wynyard on the coast Tertiary basalt unconformably overlies varved mudstones and tillites on the shore platform. Several hundred yards further east, the tillite rests unconformably on pre-Dundas Group rocks. On the shore platform immediately east of Doctors Rock varved mudstones are found closely associated with tillite near the base of the formation. The varved mudstones include many thin beds of cross-laminated sandstone and these show the cross-lamination dipping in a northerly direction. The surface of these sandstone beds is frequently ripple-marked.

* Exposure sites, subsequently referred to by capital letters, are shown in fig. 1.

Several exposures of varved mudstones (B and E) occur in cuttings on the road along Camp Creek to the reservoir and the best exposure occurs a few yards down-stream from the reservoir wall (E). All specimens of varved mudstone collected from here showed simple varves, varying in thickness from 0·8 to 8 mm. The winter layers of these specimens were also much thicker than the summer layers which in several cases were of claystone grade and which were usually no coarser than very fine siltstone with some fine erratics. These would seem to be distal simple varves (Antevs, 1951) and this is borne out by the occasional

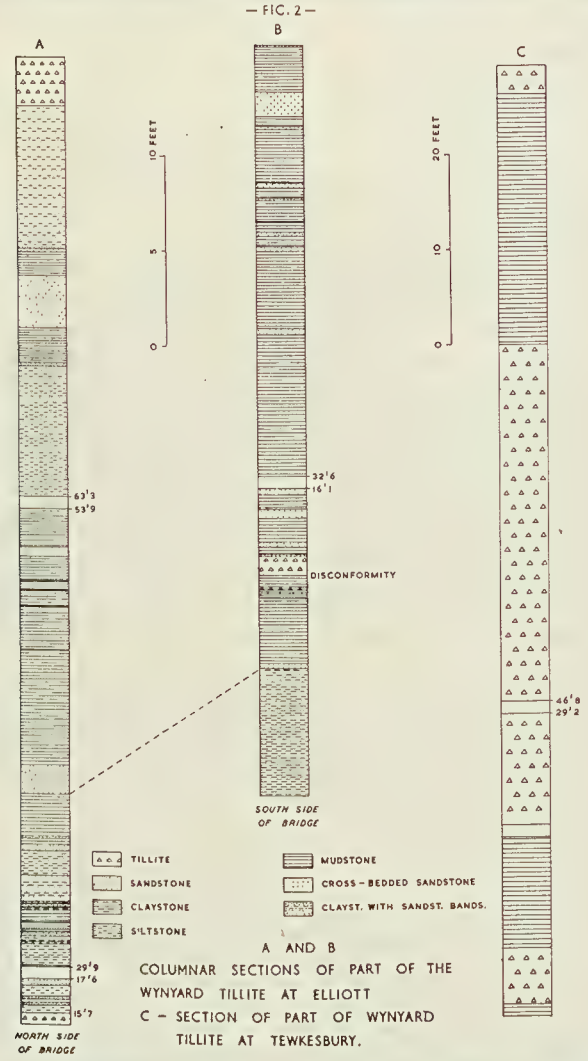

FIG. 2 (*a*).—Columnar section of part of Wynyard Tillite at Elliott.
(*b*).—Columnar section of part of Wynyard Tillite at Tewkesbury.

unvarved claystone beds. At B on the lower part of Camp Creek, the varved mudstones are associated with tillite.

In a road metal quarry beside Seabrook Creek (C) a thickness of about 20 feet of varved mudstones with erratics is revealed. The siltstone layers are ripple-marked. The most notable feature of the rocks in this quarry is the presence of elliptical concretions up to 60 cm. in length, which appear to be restricted to a narrow band. These concretions, which will be described a little later, show contorted bedding and are slump structures.

Where the West Calder Road crosses the Calder River (D) tillite can be seen at river level passing up into varved mudstones which in turn pass up into tillite as seen in road cuttings on the West Calder Road south of the bridge.

The best exposure of varved mudstones seen in the area was in road cuttings and quarries near the Seabrook Creek crossing on the Elliott-Mt. Hicks Road (F). Here, almost 100 feet of varved mudstone, tillite and fine-grained sandstone are exposed resting on tillite in the creek bed. This tillite is described in a later section. The section beside the road to north and south is given (fig. 2 (*a*)). Several granite erratics were found in the tillitic bands, the largest observed being four feet in diameter.

The section above this tillite consists of alternations of fine-grained, cross-laminated, laminae or very thin beds of sandstone, with thinly laminated and laminated sets of varved mudstone. Laminae and thin beds of tillite are present on at least eleven horizons but these seem to become rarer between 50 and 80 feet and above this they are uncommon.

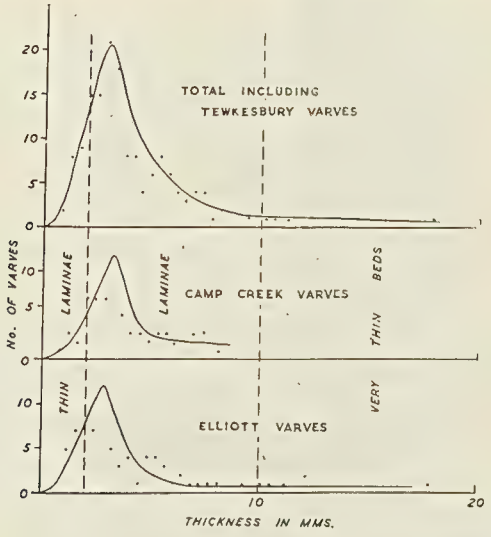

FIG. 3 – GRAPHS SHOWING DISTRIBUTION OF THICKNESS OF VARVED MUDSTONE BEDS
LIMITS AFTER McKEE AND WEIR, (1953).

FIG. 3.—Graph showing distribution of thickness of beds of the varved mudstones.

The sandstone bands are of interest, as they consist of fine-grained quartz with some clay matrix. They are dusky yellowish brown (10YR2/2) and brownish black (5YR2/1). They are thinly cross-laminated, the cross-lamination being revealed by dark bands. It was observed here and at Doctors Rock that the surfaces of these bands were usually ripple-marked. The varved mudstones were observed to be usually laminated, some thinly laminated and some very thinly bedded. Figure 3 shows the relative distribution of thicknesses of varves.

These varved mudstones were frequently highly coloured, especially on the south side of the bridge. The colour is normally olive grey, with some summer layers a light brown, but on weathering, iron minerals present are oxidised especially along joints and bedding planes, producing rich purples, reds and deep browns, which give the rock a most striking appearance.

The southernmost outcrop of varved mudstones observed was in a cutting on a disused road at Tewkesbury (G). Here three varved mudstone members are interbedded with tillites as shown in fig. 2 (*b*).

A most interesting section was examined in the bed and valley walls of the creek immediately east of Oonah Post Office (see fig. 4).

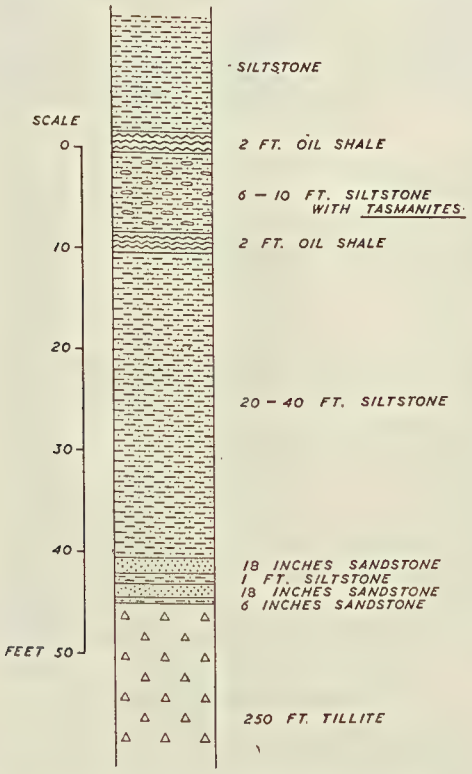

FIG. 4.—Columnar section of Permian near Oonah.

The bottom of the tillite was not seen, but at least 250 feet of this rock were exposed in the creek below and just above the falls. No sign of varved mudstones was seen in this section either in the form of outcrops or as fragments in the creek debris. The tillite is overlain by six inches of dark-grey siltstone, eighteen inches of fine-grained, white, massive, very tough sandstone, a foot of grey siltstone, eighteen inches of sandstone, again white, massive and very tough and then twenty to forty feet of dark-grey siltstone. This siltstone is followed by two beds of oil shale separated by six to ten feet of dark-grey shaly siltstone, with some spores. The top oil shale is overlain by a dark siltstone, which is in turn unconformably overlain by Tertiary basalt. Large pyritic nodules are common in all these sediments above the tillite, but fossils are rare. The importance of this section is that the oil shale contains foraminifera identified by Crespin (1947) as *Ammodiscus multicinctus* Crespin and Parr, *Hyperamminoides acicula* Parr, *Crithionin teicherti* Parr, *Pelosina hemispherica* Chapman and Howchin, *Ammobaculites woolnoughi* Crespin and Parr and *Digitina recurvata* Crespin and Parr, indicating correlation with the Latrobe Tasmanite and the Upper Marine Group of New South Wales. Thus the oil shale is Upper Artinskian in age. Because of the small stratigraphic thickness (less than 50 feet) between the oil shale and the top of the tillite, it is probable that the top of the tillite goes well into the Artinskian and that glaciers were active late in the Artinskian in this area.

Notes on the Sedimentary Petrology and Structures

Tillite

A specimen of tillite (U.T.G.D. 6055) from the base of the Elliott section was examined under the microscope. The tillite band of the fresh rock is medium dark-grey (N4). The associated siltstone is medium bluish-grey (5B5/1), but becomes light olive-grey (5Y5/1) on weathering. Claystone associated with the tillite is also medium bluish-grey. Both graded and ungraded beds are present. In the ungraded specimen (6055*b*) the modal grain size is about 0·25 mm. with about 30 per cent of the particles in the modal grade. Grains from 0·06 mm. to 2·2 mm. were measured but about 25 per cent of the band was unresolvable under the highest power of the microscope. The grains are dominantly angular, with some sub-angular and a few sub-rounded ones. Larger fragments tend to be slightly more rounded than the smaller and some have flat surfaces. The particles vary from almost equidimensional to very elongated. An orientation parallel to the bedding plane is distinctly preferred. Quartz is the only common mineral and forms about 10 per cent of the coarse band. The matrix consists of quartz, a micaceous material which may be a clay mineral and unresolvable material. Rock fragments constitute about 55 per cent of the coarse band. The rock fragments include quartz schist, quartz mica schist, carbonaceous siltstone, chloritic quartzite, quartzite, crystalline dolomite, calcite (some of which may be authigenic), graphitic mica schist, ilmenitic chloritic feldspar schist, siliceous granular limestone, puckered quartz sericite schist, plagioclase with chlorite inclusions, fossiliferous siltstone, chloritic quartz keratophyric tuff, chlorite haematite quartz rock, pyritic carbonaceous silty sandstone,

ilmenitic fragments, micaceous slightly ilmenitic sandstone and oolitic dolomite. The most common rock types are the granular limestone and graphitic mica schist and phyllite.

The fine band, with modal grainsize about 0·009 mm. and variation from 0·002-0·012 mm., contains inclusions of tillitic material up to 2·7 mm. long by 1 mm. wide. There are also distinct bands of particles from 0·015-0·02 mm., which diverge around the tillitic erratics. These coarser bands contain micaceous minerals, which are possibly clays, quartz and some calcite. The quartz and calcite grains are angular and from equidimensional to slightly elongated. The micaceous minerals in both coarse and fine bands are distinctly lath shaped and orientated parallel to the bedding plane. The finer bands are dominantly micaceous with some quartz and other minerals.

The contact between the coarse band (a tillitic arenite) and the fine band (a tillitic fine lutite) is sharp but irregular due to the uneven surface of the arenite on which the siltstone was deposited. The rock is considered as of glacial origin because of the presence of large numbers of varied rock fragments, the angularity and the poor sorting. The presence of tillitic erratics in the fine siltstone is of particular interest.

The other specimen examined (6055A) showed distinct gradation from a modal grain size of 1·5 mm. in the coarsest part down to 0·01 mm. in the finest part. Thus the rock varies from a medium arenite to a fine siltstone. Sorting is poor throughout and a considerable proportion of clay material is present, at least 15 per cent in the fine siltstone portion. Probably only 40-50 per cent of the particles would fall into the modal grade of each portion. In all grades the fragments are dominantly angular, with many sub-angular and a few sub-rounded ones. Fragments vary extremely in sphericity from almost equidimensional to elongated forms $6\frac{1}{2}$ times as long as wide. Many distinctly tabular fragments are present. Quartz varies in amount from about 10 per cent in the arenite portion to 40 per cent in the siltstone and 50 per cent in the fine siltstone fraction. Several fragments of feldspar were seen. Clay minerals or sericitic mica are abundant in the matrix and form at least 40 per cent of the finest grade of the rock. Rock fragments form about 60 per cent of the rock in the arenite grades, but are less than 5 per cent in the lutite grades. They consist of quartzite, quartz mica schist, quartz feldspar mica schist, chlorite schist, quartz schist, fine chloritic sandstone, carbonaceous siltstone with sandstone bands, serpentinite, phyllite, mica schist, spilite, laminated carbonaceous siltstones, quartz-chlorite rock, graphitic schist, and an older tillite or subgreywacke. A feature of the slide is the occurrence of about 10 per cent of carbonaceous material, much of which may be graphite, as it is flaky and oriented parallel to the bedding. Haematitic and limonitic staining is present, but not common. This rock is considered to be of glacial origin on the same grounds as the previous rock, with the additional evidence in this case of graded bedding.

Varved Mudstones

Twelve specimens of varved mudstones were carefully measured and examined under the binocular microscope and a thin section (6046*b*) was also examined.

The thin section showed portions of eight varves and details of this slide are summarised as Table I.

TABLE I

Summary of Characters of Varved Mudstone U.T.G.D. 6046 (b)

Varve No.	Thickness Component Bands	Total	Grade		Composition
			Modal	Range	
	mm.	mm.	mm.		
VIII	0·78	0·78	0·01	n.d.	clay minerals plus quartz
VII	1·20 W.L.	1·50	0·009	n.d.	—
	0·30 S.L.		0·035	n.d.	—
VI	0·42 W.L.	0·54	0·009	n.d.	—
	0·12 S.L.		0·025	n.d.	—
V	0·30 W.L.	0·60	0·009	n.d.	quartz and clay minerals equal
	0·30 S.L.		0·03	n.d.	
IV	0·54 W.L.	1·14	0·005	up to 0·009 mm.	quartz 50%, clay mins. 40%, rock fragments
	0·60 S.L.		0·03	up to 0·55 mm.	—
III	0·24 W.L.	6·88	0·005	n.d.	clay and quartz, quartz 75%, clay 25%
	3·6 S.L.		0·05	n.d.	clay 60%, quartz 40%
	0·6 5·64		0·06	n.d.	quartz 70%, clay 30%
	1·44 mm.		0·08	up to 0·16 mm.	plagioclase
II	0·66 W.L.		0·005	up to 0·009 mm.	mainly clay with some quartz
	0·12 S.L.		0·015	n.d.	quartz, clay rock fragments
	0·24 0·54	1·20	0·012	n.d.	—
	0·18 mm.		0·03	up to 0·06 mm.	dominantly quartz with some clay
I	0·42 W.L.		0·005	n.d.	dominantly clay with some quartz
	0·36 1·5 mm.	—	0·016	up to 0·23 mm.	quartz and clay
	0·72		0·009	up to 0·012 mm.	—

S.L. indicates Summer Layer.
W.L. indicates Winter Layer

Examination of this table will show that the varves are dominantly thinly laminated but varve III is laminated. The maximum grade of the summer layers is 0·08 mm. with most of them about 0·03 mm., while the maximum grade in the winter layers is 0·009 mm., with several varves showing a grade in the winter layers of less than 0·005 mm. Thus the varves vary from very fine arenites to very fine siltstones or claystones, with many of the winter layers down to the clay grade. Quartz and micaceous (or clay) minerals are dominant with only occasional fragments of plagioclase and rocks. The micaceous minerals are particularly common in the winter layers and they usually are elongated parallel or sub-parallel to the bedding. Haematitic and limonitic stains are com-

mon throughout, with some concentrations. The grains are dominantly angular, with very little rounding shown. Varves I and IV to VIII are simple varves in Antev's terminology, although Varve I has coarse bands in the winter layer. The winter layers become proportionally thicker upwards as compared with the summer layers. Varves II and III have fine layers in the summer layer and are thus the composite varves of Antevs. Varve III is especially interesting because of its thickness and the very thin winter layer as compared to the summer layer. It represents, perhaps, a year in which the glacier approached much closer than in any of the other seven years.

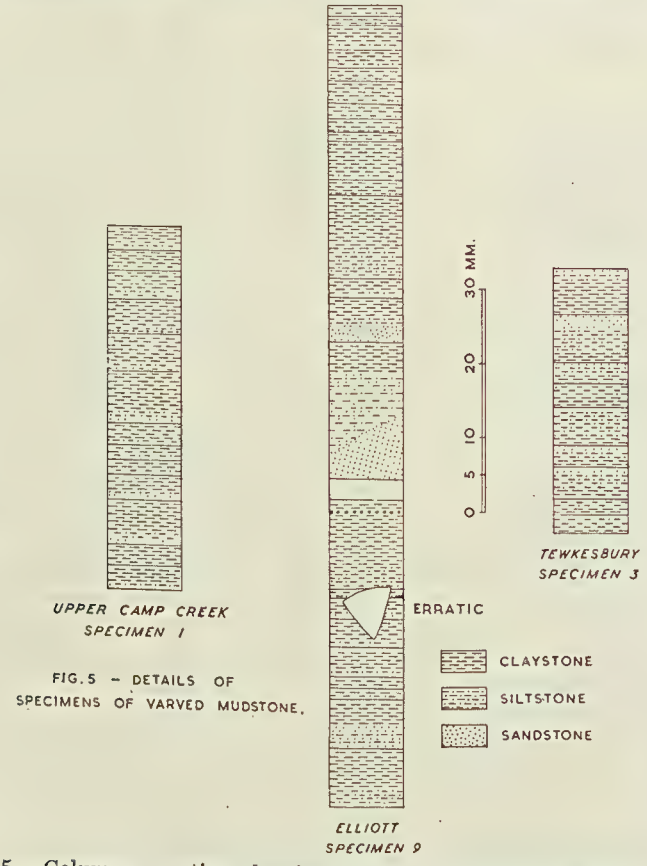

FIG. 5.—Columnar section showing details of varved mudstones—
(*a*) Specimen from Upper Camp Creek.
(*b*) Specimen from Elliott.
(*c*) Specimen from Tewkesbury.

Some details of three specimens, one from Camp Creek, one from Elliott and one from Tewkesbury, are here shown as fig. 5. The Camp Creek varved mudstones are mainly thinly laminated to laminated, with individual varves from 0·8 to 8 mm. thick. The summer layers are usually fine siltstone, with a coarse siltstone or fine sandstone in a few cases and are rarely silty claystones. The winter layers are invariably

claystone. Erratics present are usually less than 3 mm. in greatest dimension and the majority are less than 1 mm.; however, one reached 25 mm. in longest dimension. In many varves they are concentrated as a thin line at the base of the summer layer. In one or two varves a siltstone band occurs within the claystone of the winter layer. In the majority of varves measured from Camp Creek the winter layer was distinctly thicker than the summer layer and only rarely did the proportion drop to approach unity. In the case of the eighth varve of the specimen recorded as fig. 5 (*a*) the summer layer lensed out rapidly and within the specimen almost thinned out completely. The colours do not vary greatly. Summer layers are mostly dusky yellow (5Y5/4, 5Y6/4) with some pale olive (10Y6/2) and greyish orange (5Y7/4). One band was purple (5P5/2). The winter layers are dominantly olive-grey (5Y3/2, 5GY3/2, 5Y5/2, 10Y5/2, 10Y4/2, 5Y3/4). Weathering has produced ferruginous concretions in the silty layers in some cases. Sixty-seven varves were measured in specimens from this locality. All are simple varves in Antevs' (1951) terminology. Because the winter layers are usually thicker than the summer layers these varves are thought to have been formed at some distance from the ice front, i.e., they are distal varves. Because of the fine grainsize of the summer layers, the lake in which these varves were deposited is considered to have been deep at Camp Creek.

The varves measured from Elliott were from 1·2 mm. to 18 mm. thick, the latter being an exceptional figure. Most of these varves are thinly laminated or laminated, with a few very thinly-bedded. The summer layers are usually siltstone, but quite a number are fine sandstone and unusually thick; rarely the summer layers consist of very fine siltstone or silty claystone. The winter layers are dominantly claystone but a few are very fine siltstones. The winter layers commonly have bands of coarser material in them and they also commonly contain erratics up to 2 mm. and rarely up to 12 mm. in longest dimension. Erratics also occur in the summer layers and most of the erratics in the varves are less than 1 mm. in longest dimension. However, one was 2 cm. long. Concentration of erratics at the base of the summer layers was not observed in these varves as it was in the Camp Creek specimens. Much more variation in the ratio of thickness of the winter to that of the summer layer was found in the Elliott varves than in those from Camp Creek. In a number of cases from Elliott the summer layer was very much thicker than the winter layer, e.g., Varve 9 (fig. 5, *b*). In many cases the two layers were almost equal and in perhaps a very slight majority of cases the winter layer was the thicker. The colour of the Elliott varves was extremely variable probably due to oxidation on weathering and in some cases this oxidation was demonstrably joint controlled. The summer layers vary from olive-brown (5Y3/4), pink (5R8/4), pale red (10R6/2), orange-pink (5YR7/4) to other combinations of red and yellow. The winter layers are much less variable, the predominant colour being greyish-olive (10Y4/2), with olive (10Y5/2) and light olive-grey (5Y5/2). A total of 83 varves was measured from this locality. All the varves measured from Elliott are simple varves, although more from this locality have coarse bands in the winter layer than is the case with the specimens from Camp Creek. Varve 11 (fig. 5*b*) is excessively thick, being one and a half times as thick as any other varve

measured and over six times the modal thickness of the Elliott varves measured (2·85 mm. approx.), which is a little lower than that of all varves measured (3·0 mm. approx.). Six very thinly bedded varves occur among all those measured, all six being from Elliott, and it is probable that all of these are drainage varves. Because of the greater relative thickness of summer layers to winter layers in the Elliott varves as compared to the Camp Creek varves, the former are considered to have formed closer to the ice front as a whole than the latter. The Elliott varves are also generally coarser in grade in both summer and winter layers than those from Camp Creek, suggesting deposition in shallower water.

One specimen of varved mudstone from Tewkesbury was measured and contained nine varves. The thicknesses varied from 2 to 7 mm., most of the varves being laminated. Summer layers were mostly fine sandstone or coarse siltstone and winter layers mostly silty claystones or very fine siltstones. All the varves are simple. Occasional erratics up to 2 mm. occur. The colour varies from moderate greenish-yellow (10Y7/4, 10Y7/6) in summer layers to light olive-grey (5Y4/1) and greyish-olive (10Y4/2) in the winter layers. The properties of the specimen are summarised as fig. 5*c*. No general conclusions can be drawn from these observations on a single specimen.

Clay Minerals

The winter layers from several specimens from Camp Creek and Elliott were examined by differential thermal analysis by G. E. Hale who reported that the clay mineral present was kaolinite.

Sedimentary Structures

The most striking feature of the varved mudstones is the graded bedding, which is very well displayed indeed. Usually this grading is from siltstone up to claystone, but occasionally from silty claystone up to fine claystone and also from fine sandstone up to clayey siltstone. This grading is shown in Plate, figs. 2 and 3.

The bedding varies from thinly laminated in a few varves to laminated in the majority of varves (82%) and very thinly bedded in a few varves (4%) (see fig. 3). The modal thickness of the varves measured is about 3·0 mm. The associated sandstones and tillites are mostly very thin-bedded with rare one thin-bedded, but no detailed measurements were made on these. The tillites outside the varve members are frequently thick or very thick-bedded.

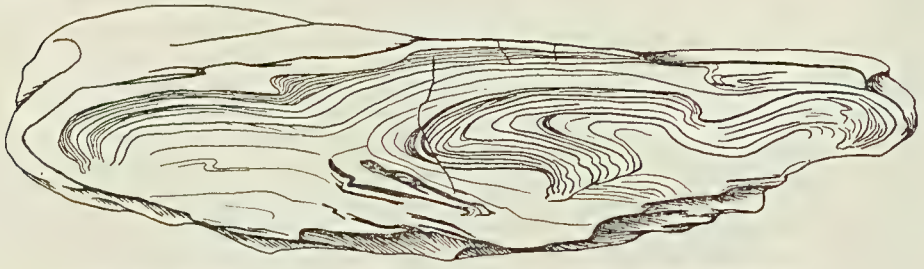

FIG. 6.—Sketch section of slump structure from Seabrook Creek.

Bedding planes in the varves are usually flat, but disturbances of two types, slumping and ripple-marking, are present. No detailed observations were made on either of these structures. Ripple-marking was seen particularly at Doctors Rock, Lower Seabrook Creek and Elliott. Many of the ripples were due to wave action and one set in the floor of the southern quarry at the Elliott locality trended just east of north. Frequently the cross-laminated sets in the varves had a rippled upper surface—in most cases wave-rippled. Most of the slump structures in the Elliott varves are extremely small folds (amplitude about 1 mm. or less) of a complicated character, on the top of the varves. They do not occur on the top of every varve. These may be associated with the beginning of circulation in the glacial lake at the onset of unusually warm spring seasons. This type of small scale slumping was not seen elsewhere but at Elliott. However, evidence of slumping on a larger scale was seen in the Lower Seabrook Creek locality. In the road metal quarry here, concretions up to 50 cm. in longest dimension are common on a restricted horizon. These concretions are discoidal with the short axis perpendicular to the bedding. Sections cut through several of these with a hacksaw showed that the siltstone bands in them were very contorted and broken with overfolds, recumbent folds and thrust faults on a minor scale. Most of these structures seem to be directed from a southerly direction. A sketch of a section of one of these is included (fig. 6). They would seem to indicate that the floor of deposition sloped down to the north. David (1907, p. 276) described similar concretions (in his coastal section) varying in length from 1 to 27 feet. However, he ascribed no origin to these.

A very noticeable feature of the varves at the Elliott locality (F.) and at Doctors Rock (A.) is the presence of numerous sets of cross-laminae interbedded with the sets of varved strata. As far as could be seen the sets of cross-laminae are tabular and laminated-to-thinly bedded. Specimens measured had sets from 4 to 22 mm. thick, but some seen in the field were thicker than this. The sets measured were all thinly cross-laminated. They were formed of brownish-black (5YR2/1) and dusky yellowish-brown (10YR2/2) fine sandstones composed dominantly of angular quartz fragments with a clayey matrix. The top surface of these sets is frequently ripple marked. Cross-laminae at Doctors Rock and Elliott indicate current directions from the south-east, south, or south-west.

Age and Palaeoecology

Age

The base of the Wynyard Tillite is exposed at several places on the shoreline east of Wynyard. The tillite rests here with marked angular unconformity on rocks of Lower Cambrian or Precambrian age, which are steeply folded, while the tillite dips slightly to the north-west. The tillite itself contains fragments of fossiliferous rocks as young as Lower Devonian (e.g., Florence Quartzite is common as erratics) as well as granites, lithologically very similar to those thought to have been intruded in the Middle Devonian. The upper age limit of the Wynyard Tillite has not previously been fixed with any certainty, but the section observed

at Oonah now provides this limit. The oil shale, 30-50 feet above the top of the tillite contains foraminifera which suggested to Crespin (1947, p. 15) a correlation with the lower part of the Upper Marine Group of New South Wales. This group is considered by Teichert and Fletcher (1943, p. 159) to be of " Artinskian age or only slightly younger." Thus, unless a long diastem has been overlooked, it is probable that the top of the Wynyard Tillite is high in the Artinskian. As this formation is probably the product of essentially continuous, fairly rapid deposition, its base is unlikely to be older than Sakmarian. Thus, until more positive fossil evidence is available, the Wynyard Tillite will be regarded as of Sakmarian and Artinskian age.

Palaeogeography

The composition of the erratics in the tillite and varved mudstones as observed in the field and under the microscope adds little to the list of rock types provided by David (1907) and Kitson (1902). All were recognisable or deducible as belonging to Precambrian, Cambrian, Ordovician, Silurian or Devonian Systems as developed in Western Tasmania. Cross-lamination seen at Elliott, Lower Seabrook Creek and Doctors Rock indicated currents from a southerly direction and the slump structures indicate that the original floor of deposition sloped down to the north. These deductions are in accord with the provenance of the erratics and confirm the idea of an ice-covered land to the south and south-west.

At the beginning of the Permian, ice-sheets probably covered the whole area and as they retreated southward they left thick deposits of ground moraine behind them on the land surface. Glacial lakes developed on this moraine where streams were dammed by surface irregularities, terminal moraines or subsidiary glaciers. In these lakes varved muds were deposited and in some years the winter was interrupted by warm spells, resulting in the deposition of coarser layers in the winter clays or fine silts. These coarser layers may have been the result, on the other hand, of sudden access of new drainage from a subsidiary lake in which the moraine or ice barrier was suddenly removed. This sort of event certainly happened as is shown by the presence of drainage varves at Elliott. If the varves at Camp Creek and Elliott were deposited in the same glacial lake, as is possible, the lake was deeper at Camp Creek than at Elliott and Elliott was closer to the source of the varved muds than was Camp Creek as shown earlier. Minor variations in the intensity of glaciation are indicated by the presence of thin tillite beds in the varves, indicating short-term advances of the ice-sheet. Beds of cross-laminated normal sandstones may indicate short-term retreats whereby more water was made available to the streams flowing from the ice-front. Because of the retreat, these streams had to carry the rock-flour and boulders greater distances, thus producing normal sandstones by sorting. Major advances of the ice-front are recorded where varves are overlain by thick tillites and this is seen to have occurred at least three times by the succession in the disused road at Tewkesbury. The exact number of advances and retreats of the ice front cannot yet be stated. Much more work remains to be done before the detailed palaeogeographical history of the area is finally elucidated.

As the ice retreated for the last time the sea flooded in over some barrier, probably to the north, and pyritic siltstones and sandstones, with a few marine fossils, were deposited. The water may well have been brackish, which would account for the rarity of fossils. Poor circulation is indicated by the presence of pyrite nodules and carbonaceous matter and this suggests a partially closed, cold-water basin. Shallow water, poor circulation conditions with the accumulation of gymnosperm spore cases resulted in formation of the oil shale, probably near an old shore line.

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LOCALITY INDEX

Calder River	Burnie	28	41° 5′	145° 38′
Camp Creek	Burnie	28	41° 2′	145° 48′
Doctors Rock	Burnie	28	41° 0′	145° 47′
Elliott	Burnie	28	41° 6′	145° 47′
Hellyer Gorge	Burnie	28	41° 17′	145° 37′
Mt. Hicks	Burnie	28	41° 5′	145° 45′
Oonah	Burnie	28	41° 14′	145° 43′
Seabrook Creek	Burnie	28	41° 1′	145° 47′
Tewkesbury	Burnie	28	41° 13′	145° 45′
Wynyard	Table Cape	22	41° 1′	145° 42′

Fig. 1.—Photomicrograph of tillite (spec. U.T.G.D. 6055 (*b*)).

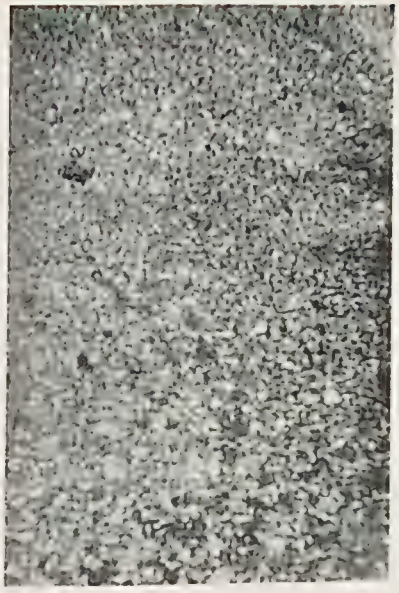

Fig. 2.—Photomicrograph of varved mudstone (spec. U.T.G.D. 6046 (*b*)).

Fig. 3.—Photograph of varved mudstone from Elliott showing grading and slumping.

Papers and Proceedings of the Royal Society of Tasmania, Volume 89

The Permian Rocks of Woody Island, Tasmania

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(with 2 text figures and 1 plate)

Abstract

The Permian section at Woody Island, Tasmania, begins with a pyritic siltstone, passes upwards through glendonitic, pyritic sandstone, siltstone and sandstone, tillite, siltstone and sandstone, a thin bed of bryozoal limestone and finally into a fossiliferous siltstone tentatively correlated with the Porters Hill Siltstone at Sandy Bay and the Bundella Mudstone at Mt. Nassau. The seventeen units, referred to nine formations, total about 330 feet and are considered to be Sakmarian and Lower Artinskian. The section is well-exposed in cliffs and on a shore platform developed just below high tide mark. A fault striking north-west and down throwing at least 260 feet to the east cuts the island.

Introduction

A visit by M. L. Yaxley to the island in 1953 showed that a good Permian section was exposed there and this was subsequently measured by all three authors. The island, situated about half a mile off Alonnah, Bruny Island, in D'Entrecasteaux Channel, has an area of about 70 acres and a height of about 120 feet. It is rimmed by cliffs up to 50 feet in height and a shore platform up to 20 yards wide at low tide. The only previously published report on the geology of Woody Island is by Scott, Roberts and Hobbs (1861) which mentions limestone on Satellite (Woody) Island.

We are greatly indebted to Mr. George Dibbern, owner of the island, for his hospitality during the visits.

Physiographic Notes

The island has a gently rolling surface from about 50 to 120 feet above sea-level. Drainage from it is poor due to the relatively impermeable siltstones. What valleys are present are joint controlled or along the fault which intersects the island. The weathering is deep and produces clayey podzolic soils of which some are very pale. The fault acts as a passage for groundwater as evidenced by the seepages where it intersects the cliffs.

FIGURE 1 GEOLOGICAL SKETCH MAP OF WOODY ISLAND, TASMANIA.

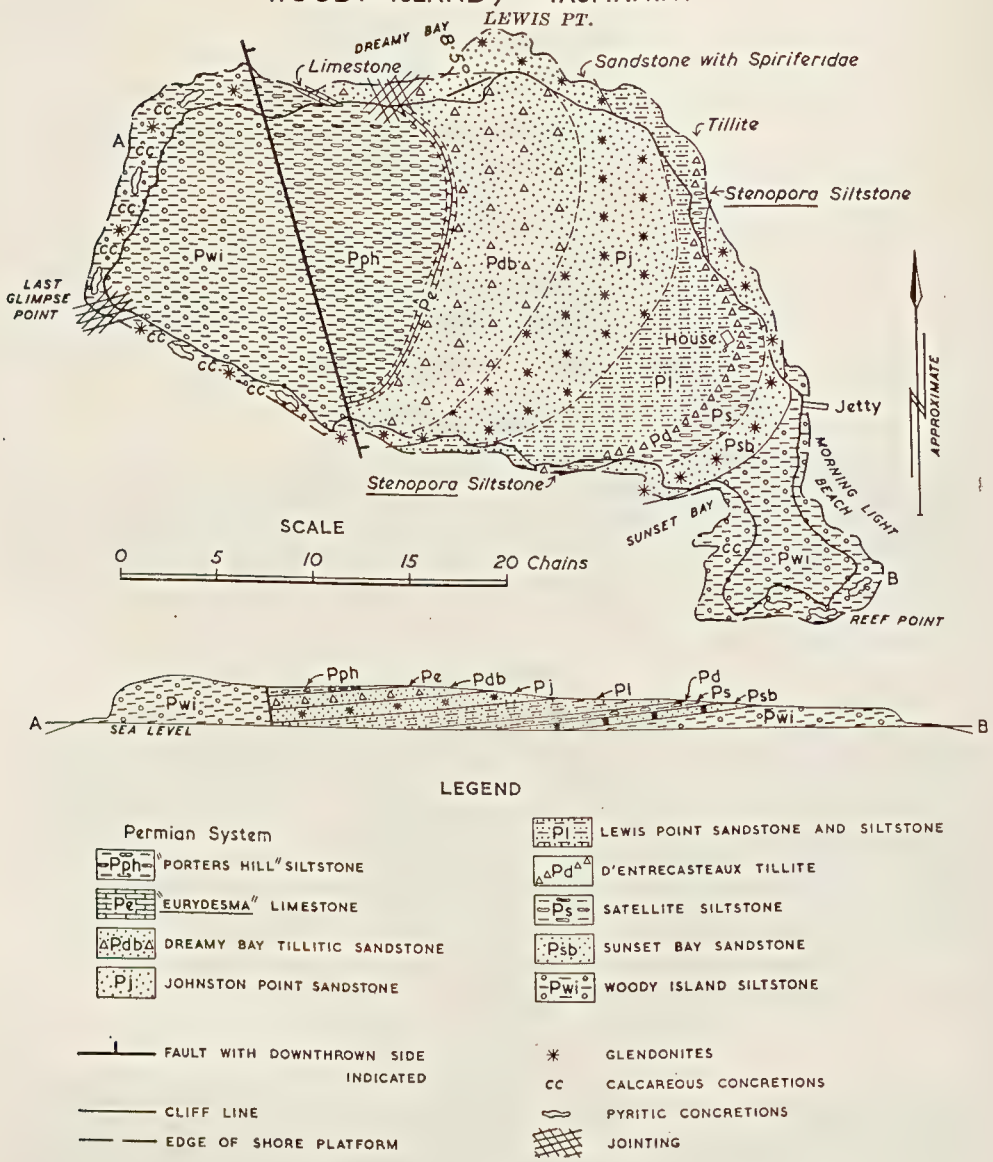

FIG. 1.—Geological Map and Section of Woody Island.

The Topographic Nomenclature Board ruled that Johnston Point be replaced by Lewis Point as another Johnston Point exists. The Johnston Point Sandstone of this paper is here renamed Alonnah Sandstone.

Steep cliffs have been developed by marine undercutting in the soft sediments and the cliffs are almost everywhere flanked by a wave-cut platform which is just flooded at high tide. The platform is interrupted by joint-controlled chines, by fallen blocks, and, at the western end of the island, by undercut masses of calcareous concretions, slightly more resistant than the enclosing siltstones. Landslips occur in the clayey soils in several places. The island is being actively eroded by the sea at the present time, the only depositional features being small pocket beaches of shingles.

Permian Rocks

The island is composed entirely of rocks of Permian age, good sections being exposed from the eastern end to the fault which roughly bisects the island. A sketch geological map of the island is included as fig. 1 and the succession is summarised in columnar form in fig. 2. Essentially the section is siltstone and sandstone with two tillitic bands and a thin bed of limestone. Seventeen units were measured but these could be grouped for mapping and description into nine formations.

Woody Island Siltstone

The Woody Island Siltstone is that formation of pyritic siltstone at least 86 feet thick as exposed on the eastern end of Woody Island where it is overlain by the Sunset Bay Sandstone. The underlying formation is not exposed. The formation contains *Eurydesma cordata*, crinoid columnals, and worm burrows. Its age is considered to be Sakmarian.

The lower member of this formation as exposed at the eastern end of the island is 73 feet thick and consists of blue-grey siltstone with rare erratics of quartz and quartzite and rare marine fossils. Bedding is thick to very thick but the rock breaks easily but irregularly into small blocks. Concretions of pyrite are very common. They are irregular in shape and orientation but there is a preference for elongation perpendicular to the bedding. Concretions of calcite up to twelve feet in diameter are also common and are lenticular with the greatest diameter parallel to the bedding. In places they contain small disarticulated crinoid columnals and some of them, when viewed from a distance, show rough cross-bedding. Large lenticular concretions, apparently of siltstone, with marked concentric fissility are also present in the cliffs at the eastern end of the island. Another feature of interest is the occurrence of alum efflorescence on the cliffs cut in this member. This would be the result of the attack of sulphuric acid, from the oxidation of the pyrite, on the clay minerals in the siltstone. The fossils in this lower member include small individuals of *Eurydesma cordata* but fossils are rare.

The upper member of this formation east of the fault is a well-sorted, yellow to white, siltstone with rare erratics of aplite and rare pyritic concretions. Worm tracks and burrows are common in this member and a few small pelecypods also occur. It is finely cross-bedded. Arrowhead markings in this member probably represent infilling of worm burrows.

FIGURE 2 COLUMNAR SECTION OF PERMIAN ON WOODY ISLAND

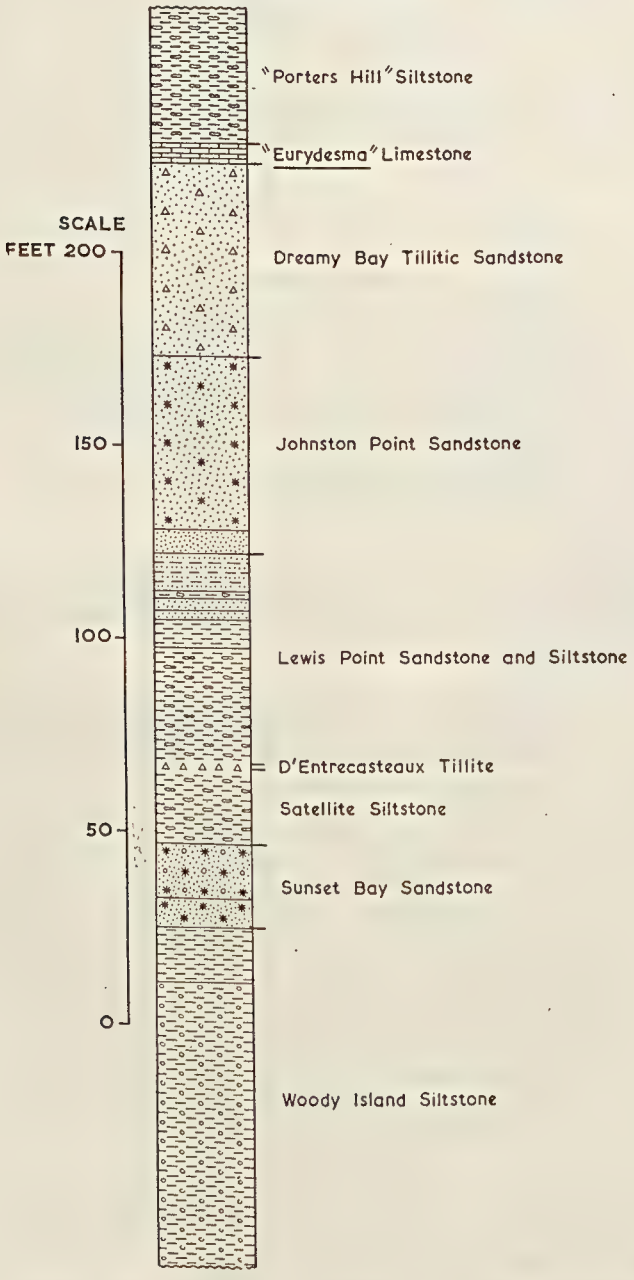

FIG. 2.—Columnar section of Permian on Woody Island.

West of the fault, the island consists entirely of a dark-grey siltstone with large pyritic concretions, large lenticular calcareous concretions and numerous glendonites, as large single crystals, stars of four large crystals or as rosettes of numerous small crytals. One single crystal measured was 20 cms. long. Fossils are rare but include *Eurydesma cordata* and others. This is included as a member of the Woody Island Siltstone on the grounds of extreme lithological similarity but is considered to lie below the lower member exposed at the eastern end of the island because no glendonites occur there.

Sunset Bay Sandstone

The Sunset Bay Sandstone is that formation of sandstone, 21 feet in thickness, which overlies the Woody Island Siltstone and is overlain by the Satellite Siltstone as exposed on the northern side of Woody Island. Fossils are rare but include *Eurydesma cordata*. The formation is Permian, probably Sakmarian. Sunset Bay, after which the formation is named, is on the southern side of Woody Island.

This formation consists of two units, both of which are well-sorted, fine-grained sandstones with a few erratics of granite and quartzite. The grains are angular. Quartz is the only mineral identified macroscopically in the lower unit and quartz and feldspar are present in the upper unit. Bedding in both is thick and cross-bedding occurs in the lower member. Both are grey, or mottled dark and light-grey in colour. Glendonites are present in both units and one from the lower unit is illustrated (plate I). The higher unit contains pyrite concretions but these are not large. In the lower unit worm tracks and burrows are common but macrofossils are rare, only *Eurydesma cordata* being collected.

Satellite Siltstone

The Satellite Siltstone is that formation of fossiliferous siltstone 20 feet thick, overlying the Sunset Bay Sandstone and overlain by the D'Entrecasteaux Tillite on the northern shore of Woody (or Satellite) Island. It contains many fossils but especially noticeable is *Stenopora tasmaniensis*. It is Permian, and probably Sakmarian, in age.

The Satellite Siltstone is a richly fossiliferous siltstone with thick bedding, good sorting and rare erratics. Quartz and feldspar are present and the siltstone is a medium dark-grey (N 4) in colour and has a blocky fracture. The most noticeable feature of the formation is the abundance of fossils which form at least 20 per cent of the rock and, on the southern shore, are preserved as the original skeletons. Dominant in numbers among these is *Stenopora tasmaniensis* which forms dense mats at a slight angle to the bedding. The ramose colonies are markedly oriented, the main direction being to the north-east, as if they had been oriented by currents flowing from the south-west. Other fossils are listed below:

Bryozoa.

Stenopora tasmaniensis	very common
Stenopora spp.	v.c.
Fenestella dispersa	c.
Fenestellidae	v.c.
Streblotrypa marmionensis	rare

Brachiopoda.	
Strophalosia spp.	v.c.
Grantonia hobartensis	few to common
"*Martiniopsis*" sp.	few
Spiriferidae	common
Mollusca.	
Merismopteria macroptera	rare
Deltopecten sp.	common
Mourlonia sp.	common
Echinodermata.	
Calceolispongia sp.	few disarticulated columnals
Jimbacrinus sp.	radials, basals and brachials

D'Entrecasteaux Tillite

The D'Entrecasteaux Tillite is that formation of tillite six inches thick underlain by the Satellite Silstone and overlain by the Lewis Point. Sandstone and Siltstone as exposed on the northern shore of Woody Island. Fossils are rare and are mainly spiriferids. The age is Permian and probably Sakmarian. The formation is named after the D'Entrecasteaux Channel, in which Woody Island occurs.

This formation is a medium-grained sandstone with poor sorting and angular to sub-angular grains. Quartz is the main mineral in the matrix but feldspar is also present. Sub-rounded to facetted erratics of sandstone, schist and slate are common. The cement is kaolinitic, the colour dark bluish grey and the bedding thick. Spiriferids are rare and are essentially the only fossils.

Lewis Point Siltstone and Sandstone

The Lewis Point Siltstone and Sandstone is that formation of siltstone and sandstone 54 feet thick underlain by the D'Entrecasteaux Tillite and overlain by the Johnston Point Sandstone as exposed along the northern shore of Woody Island. It is fossiliferous, the fossils including *Grantonia hobartensis*, *Mourlonia* sp., *Platyschisma ocula* and *Eurydesma* sp. It is Permian, and probably Sakmarian, in age. Lewis Point is on the northern shore of Woody Island.

This formation consists of a rough alternation of siltstone and sandstone. The lowest member is a coarse fossiliferous siltstone composed of quartz and feldspar in a clayey matrix with a few rounded erratics up to 8 cms. in diameter of claystone, quartz and granite. The beds are thick and the fracture is blocky. Cross-bedding and slump structures on a very small scale are present. The siltstone is light blue-grey and fossils are common. The fossils include *Grantonia hobartensis* and other spiriferids, *Stenopora* sp., *Eurydesma* sp., *Mourlonia* sp. and *Fenestella* spp. in the lowest 11 feet. After an unfossiliferous section to 23 feet there are four feet of fossiliferous siltstone with *Neospirifer* spp., *Stenopora* sp., *Platyschisma ocula* (rare), large aviculopectinids, and *Eurydesma* sp. The top three feet of siltstone contain many fenestellids, "*Martiniopsis*" spp. and crinoid columnals.

This unit is followed by a greenish grey (5 GY 6/1), micaceous, fossiliferous siltstone without erratics and with lenticular clayey concretions up to three feet in diameter. This siltstone has thick bedding and

poor fissility. The fossils which are few in number are mainly small pelecypods including *Parallelodon costellata* (McCoy), *Nuculana darwini* (de Koninck) and *Edmondia* sp. The strophomenid *Streptorhynchus* sp. is also present. Small rectangular carbonaceous fragments are common but their relationship is unknown.

A fine micaceous, white or yellowish sandstone follows. The sorting is good and both quartz and feldspar are present. The cement is clayey and the sandstone is friable where exposed. The bedding is thick. The bounding surfaces with adjacent units are irregular, suggesting penecontemporaneous erosion. Pelecypods and *Fenestella* occur in patches.

Three feet of fine-grained, well-sorted quartz sandstone, of bluish-grey colour, follows. Bedding is very thin but the rock splits massively. Occasional worm tracks are the only fossils. A well-sorted fine-grained, sandstone with sub-angular fragments of quartz and feldspar in a clayey matrix is the next unit. It is light grey in colour and has rare erratics of quartzite and slate. Pentagonal crinoid columnals are common in this member and are associated with pelecypods and numerous *Stenopora* prob. *tasmaniensis*. It is thickly bedded. These last two rock types alternate for the topmost 10 feet of the formation.

Johnston Point Sandstone (Here renamed Alonnah Sandstone (see footnote page 220.)

The Johnston Point Sandstone is that formation of glendonitic sandstone 51 feet thick overlying the Lewis Point Siltstone and Sandstone and underlying the Dreamy Bay Tillitic Sandstone on the northern shore of Woody Island. Fossils are very common and include *Eurydesma cordata, Strophalosia clarkei* and *Calcitornella stephensi*. It is Permian, and probably Sakmarian or early Artinskian, in age.

The lower member is a spiriferid sandstone of medium to fine grain-size, with poor sorting and erratics forming up to 15 per cent of the rock. The erratics are up to 8 inches in diameter and include quartz, quartzite, granite, schist, sandstone and slate. The matrix consists of angular to sub-angular grains of quartz (about 60 per cent of the rock) and feldspar. The rock is grey and has thick bedding. The cement is mainly clayey but may be calcareous in part. Fossils, as the original shells, form up to 25 per cent of the rock and are mainly spiriferids such as *Trigonotreta stokesii, Grantonia hobartensis* and *Neospirifer* spp. Other fossils include Aviculopectinidae, *Eurydesma cordata, Merismopteria macroptera, Strophalosia* spp. and *Stenopora* sp. Although many of the fossils are broken, some are complete but they lack orientation.

The higher member is mineralogically and texturally very similar. It is light olive grey (5Y6/1) when fresh but weathers brownish yellow. The bedding is thick but due to the abundance of fenestellids some parts are laminated, and others thinly bedded. Arrowhead markings, representing infilled worm burrows, are common. Fossils are very common and are predominantly productids but fenestellids are also common. The fossils include: *Calcitornella stephensi, Stenopora* sp., *Polypora ampla, Polypora* spp., other fenestellids, ? *Anidanthus* sp., "*Martiniopsis*" sp., *Neospirifer* spp., *Grantonia hobartensis* and other spiriferids, *Eurydesma cordata, Merismopteria* sp., *Aviculopecten* sp., *Platyschisma ocula, Mourlonia* sp. and pentagonal crinoid columnals. *Strophalosia clarkei* and

other *Strophalosia* spp. are very common. Ostracodes are rare as also are plant fragments. *Spiriferina duodecimcostata, Dielasma* sp. and *Stutchburia* sp. are also present.

Glendonites occur in this formation as external moulds on the southern side of the island.

Dreamy Bay Tillitic Sandstone

The Dreamy Bay Tillitic Sandstone is that formation of poorly-sorted, erratic-rich sandstone 50 feet thick resting on the Johnston Point Sandstone and overlain by the "*Eurydesma*" Limestone as exposed on the northern shore of Woody Island. Fossils include *Stenopora tasmaniensis* and *S. johnstoni*. Its age is Permian and probably Sakmarian or early Artinskian. Dreamy Bay is on the northern side of Woody Island.

This sandstone is medium-grained, dark-grey, thickly bedded and poorly sorted. The grains and erratics in it are angular fragments of granite, limestone, quartzite and quartz. Both quartz and quartzite are very common in the erratics and in the matrix. Fossils are also abundant, haphazardly arranged and the bryozoans frequently broken. The texture suggests quite strong current conditions. The fossils include large sheets of *Stenopora johnstoni* and branches of *S. tasmaniensis*. The original shell material is usually preserved.

"Eurydesma" Limestone

No formal definition of this unit is offered here as it is hoped shortly to publish a detailed account of the stratigraphy of Maria Island with formal definitions of the units including the "*Eurydesma*" Limestone.

Although this unit is only five feet thick, it is an important one for correlation. It is a limestone, composed of fine-grained calcite as a matrix with rare, small erratics. Crinoid columnals and calyx plates are common. It is medium-grey (N 5) in colour and the fossils which are of all sizes, are extremely common. *Stenopora tasmaniensis* is the main form present but *S. johnstoni* also occurs as also does *Eurydesma cordata*. *Calcitornella stephensi* is revealed in thin sections. It is a thick-bedded bryozoal, crinoidal limestone. It is correlated with the "*Eurydesma*" Limestone of Maria Island on the evidence of the *Stenopora* spp. and *Eurydesma cordata* as well as on lithology. It was probably formed in deeper water than the limestone on Maria Island. It is also correlated with the Permian Limestone at Lilydale on the east Tamar, on the grounds of the presence of *Calcitornella stephensi*.

"Porters Hill" Siltstone

The final formation measured east of the fault is a fossiliferous siltstone composed of sub-angular grains of quartz and feldspar in a clayey matrix. It weathers to a buff colour and consists of alternating thickly-bedded and thinly-bedded to laminated layers. Erratics are few but fossils are abundant and include bryozoa in sufficient numbers to cause lamination of the rock.

The fossils include *Keeneia platyschismoides, Eurydesma cordata*, &c. This formation is correlated with the beds in the cliffs above the shoreline at Porters Hill, Sandy Bay, the Porters Hill Beds of Johnston, 1888, and the Bundella Mudstone of the Mt. Nassau section on the evidence of lithological similarity and the occurrence common to all three of *Keeneia platyschismoides, Eurydesma cordata*, and abundant ostracodes.

Structural Geology

The beds dip slightly west of north at about 8° and are intersected by a fault striking about 335° M near the western end of the island. The fault downthrows to the north-east by at least 250 feet. Jointing at 335° M and 45° M occurs close to the fault with jointing at 75° M and sheet jointing at 45° M on the western tip of the island. A sketch section, fig. 1, illustrates the structure.

Correlations and Age

The evidence for correlation within Tasmania of the formations exposed on Woody Island has been given where appropriate in the preceding text. However, the correlation of these formations with formations outside Tasmania has not been considered, and it is useful to do so here.

The species important for correlation are the foraminifera *Calcitornella stephensi,* the bryozoa *Stenopora johnstoni* and *S. tasmaniensis* and the gastropod *Keeneia platyschismoides. Calcitornella stephensi* occurs (Crespin, 1947, pp. 11-12) in New South Wales in the Lower Marine Group in the Lochinvar, Allandale and Farley Stages. However, Osborne (1949, p. 222) records it only from the Allandale Stage, although from his text (p. 214) it is clear that the actual horizon is that described by Chapman and Howchin (1905) from Pokolbin which is at the base of the Rutherford Stage. At this level foraminiferal limestones occur and it is tempting to correlate the "*Eurydesma*" Limestone on Woody Island with these limestones in New South Wales, and such a correlation would certainly not be far wrong. It is probable on the evidence of *Calcitornella* that the "*Eurydesma*" Limestone is equivalent to part of the Lower Marine Group and most probably to the lower part of the Rutherford Stage. Crockford (1951, p. 110) records *Stenopora johnstoni* from the Allandale and Rutherford Stages and Osborne (1949, p. 222) records *S. tasmaniensis* from the Rutherford Stage. The occurrence of these two species together with *Calcitornella* in the "*Eurydesma*" Limestone of Woody Island strongly suggests correlation with some part of these two stages. *Keeneia platyschismoides,* here recorded for the first time from Tasmania, is restricted in New South Wales to the Lower Marine Group and Osborne records it only in the Allandale Stage. In Tasmania it is found at Woody Island in the beds above the "*Eurydesma*" Limestone, at Porters Hill, Sandy Bay, in the beds just a few feet above high-water mark, and in a road cutting half a mile beyond Rathbone's Lime Kiln on the Lyell Highway, in the Bundella Mudstone. This suggests that these beds are about equivalent to the top of the Allandale Stage, and are certainly equivalent to a part of the Lower Marine Group.

In Western Australia the range of *Calcitornella stephensi* is from the Callytharra Limestone to the Quinannie Shale but it is commonest in the Callytharra Limestone (Teichert, 1952, and Crespin, 1947). Other fossils from Woody Island which also occur in Western Australia are *Streblotrypa marmionensis,* here recorded for the first time from Tasmania, *Calceolispongia* sp. and *Jimbacrinus* sp. The presence of these forms indicates that even at an early stage in the Permian a relationship existed between the faunas of Western Australia and Tasmania. *Streb-*

lotrypa marmionensis occurs over a wide stratigraphic range in Western Australia as also do *Calceolispongia* spp. *Jimbacrinus* sp. has been recorded from only one area in Western Australia and it is too early to know if it has any stratigraphic value. The "*Eurydesma*" Limestone of Woody Island is therefore most likely equivalent to the Callytharra Limestone of Western Australia but may be as young as the Quinannie Shale. According to Teichert (1952, p. 122) the Callytharra Limestone is Artinskian in age but probably close to the base of the Artinskian, so that it is possible that the underlying formations at Woody Island are Lower Artinskian or more probably Sakmarian.

Finally, it might be emphasised that the "*Eurydesma*" Limestone of Woody Island is *not* equivalent to the Berriedale Limestone of the Hobart district and Maria Island but is much lower in the section.

Summary

The Lower Permian section on Woody Island consists of the Woody Island Siltstone at the base followed by the Sunset Bay Sandstone, the Satellite Siltstone, the D'Entrecasteaux Tillite, the Lewis Point Sandstone and Siltstone, the Johnston Point Sandstone, the Dreamy Bay Tillitic Sandstone, the "*Eurydesma*" Limestone and the "Porters Hill" Siltstone. The total thickness of the section is about 330 feet. The "*Eurydesma*" Limestone is correlated with the limestone near the base of the Rutherford Stage of the Lower Marine Group of New South Wales and the Callytharra Limestone of Western Australia and the whole section on Woody Island is considered to lie within the time range of the deposition of the Lower Marine Group of New South Wales. The formations below the "*Eurydesma*" Limestone may be Sakmarian while this formation and the higher one are probably Artinskian.

Glendonites occur in the Woody Island Siltstone, the Sunset Bay Sandstone and the Johnston Point Sandstone.

The Permian section is cut by a north-westerly trending fault with a throw of at least 260 feet down to the east.

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LOCALITY INDEX

	Internat. Grid. Reference K/55 Quadrangle		S. Lat.	E. Long.
Lilydale	Pipers Riv.	31	41° 14′	147° 13′
Maria Island	Maria Is.	77	42° 35′	148° 4′
Sandy Bay	Hobart	82	42° 54′	147° 20′
Woody Island	Dover	94	43° 19′	147° 13′

Plate I.—Photograph of glendonite.

Clay Minerals from Permian Strata of Tasmania

By

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and

K. G. Brill
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(with 1 text figure)

Abstract

Detailed investigation of the Permian System in Tasmania has led to the identification of montmorillonite, nontronite and glauconite. Apart from the fact that these minerals have not been recorded previously in the Permian of Tasmania they have proved useful as stratigraphic marker minerals.

Montmorillonite

While measuring detailed stratigraphic sections of the Berriedale Limestone, Brill noted several beds of tan, waxy-looking shale. The shale beds range from 6 inches to a fraction of an inch in thickness and are interbedded with mudstone and limestone. The shale weathers rapidly and for this reason is best observed in the relatively fresh exposures in limestone quarries. Figure 1 shows columnar sections of the principal limestone quarries in the Derwent River valley. At the Glenorchy quarry (Weily's Blue Stone Quarries Prop., Tolosa St.) at least 11 beds and perhaps 14 beds of tan shale may be seen.

These shales are unique in Tasmania but are similar to " metabentonites " of Paleozoic age in North America. These facts led Hale to test the shale by Differential Thermal Analysis and by X-Ray diffraction methods. The tests indicated that the chief component of the shale was the mineral montmorillonite. In most samples illite was admixed.

Samples were sent to Dr. R. E. Grim, University of Illinois, who states: " The clay mineral composition of the three samples is substantially the same. In each case, they are composed of a mixed layer sequence of montmorillonite and illite and I would estimate that the montmorillonite is slightly the more abundant.

A considerable study of bentonites from the Paleozoic in this country has shown about the same clay mineral composition as your samples.

I would say on the basis of these clay mineral analyses that the samples could well be bentonites."

The shale beds are relatively pure, contain no pebbles and in only a few places are fossils present. The fossils are delicate forms such as fenestellid fronds and paper thin crinoid plates. Many of the beds are very thin but seem to pinch and swell. Some show that fragments of the tan montmorillonite-shale are jumbled and mixed with darker illitic shale. If deposition took place close to wave base the sediment would tend to fill holes in the sea floor, and be winnowed off the higher areas. A change in wave base might break up slightly consolidated clay and mix it with the surrounding sediments. The normal clay mineral being derived from the surrounding land seems to have been illite; however, much of the mudstone in the Berriedale Limestone seems to consist of rock-flour and is not clay.

Montmorillonite can form by residual weathering under various conditions (Ross and Hendricks, 1945). It has been found in glacial drift weathered under certain climatic conditions; it results from the weathering of basic igneous rocks; or it is an alteration product of volcanic dust.

The montmorillonite-bearing shales of the Berriedale Limestone are certainly not residual weathered glacial deposits. Their homogeneity and thinness precludes a glacial origin. No large areas of basic igneous rocks seem to have been available for weathering during Permian time and few fragments of basic rocks have been found in the Berriedale Limestone.

Montmorillonite-bearing shales resulting from the alteration of volcanic dust may contain shards of volcanic glass and usually contain minute, euhedral fragments of biotite, apatite, and zircon. The older the deposit the less likely that the shards will remain. Thin-sections of the Tasmanian shale were examined for shards, but none were seen. The presence of ice-rafted glacial debris in the Permian of Tasmania creates an unusual problem in connection with the presence of biotite, apatite and other igneous minerals. At least one fragment of euhedral apatite was found in a thin-section; however, there is the possibility that this could have been transported by an iceberg and dropped in the clay, instead of being wind borne.

The following facts favour the volcanic origin of the shale:—

(1) It occurs in thin, rather homogeneous beds;
(2) Although the surrounding beds are highly fossiliferous the shale is usually devoid of fossils, and where fossils occur they are few in number and represent delicate forms;
(3) The shale is megascopically identical with deposits of Paleozoic volcanic dust which occur in other parts of the world.

The montmorillonite-bearing shales have proved to be useful marker beds in the Berriedale Limestone (Fig. 1). The shale tends to weather rapidly and cannot be seen readily except in quarry faces where fresh rock has been exposed. In the limestone quarries near Dromedary and Granton in the Derwent Valley, the lower and upper marker beds, which are beds of shale separated by about 16 feet of limestone, can be traced for nearly 10 miles. Were exposures available, these beds undoubtedly could be traced farther.

There are beds of similar shale on Maria Island and at Friendly Beaches on the East Coast in a limestone formation that is coeval with the Berriedale. At present it is not possible to make a bed-for-bed correlation between the East Coast shales and those of the Derwent Valley. No shale of this type occurs in equivalent limestone beds near St. Marys.

The number of beds of montmorillonite-bearing shale is greater in the Glenorchy quarry than in the others. Although the exposure is greater, the number of shale beds per foot is also greater. The thickness of the beds is too variable to draw any conclusions as to the direction of thickening of the shales. It is tentatively suggested that the volcanic centre from which the dust was derived may have been somewhere east of Hobart.

A one inch bed of white montmorillonite-bearing clay occurs in the road cut at Elephant Pass, six miles east of St. Marys. This bed is in the Ferntree Mudstone and lies 73 feet below the Permian-Triassic contact. Montmorillonite has not been detected in clay beds of Ferntree age in other parts of the State. If this clay represents a fall of volcanic dust, the dust presumably had a source different from that which yielded the Berriedale deposits.

Nontronite

A brown, waxy-looking clay was found by Brill while measuring a detailed stratigraphic section of the Grange Mudstone (Grange Quarry, Sandy Bay Road). Subsequently the same type of clay was found in strata of approximately the same age as the Grange Mudstone about 7 miles west of Judbury. This locality is in a borrow pit next to the road at the top of the divide between the Russell River and Little Denison River. Here the clay is apple green and waxy-looking.

Differential Thermal Analyses of the mineral made by Hale show that it is chiefly the clay mineral nontronite. The mineral has not been known previously in the Tasmanian Permian.

The clay is not bedded at either locality. At the Grange quarry it occurs near the base of the face in stringers about $\frac{1}{4}$ inch wide. The stringers, which fill joints in the mudstone, cut diagonally across the bedding. At the Russell River locality, the clay forms small lumps and nodules about the size of a hen's egg. It seems to occur in joints in the mudstone.

At both localities the Permian mudstones are close to dolerite intrusions. It is possible that the nontronite resulted from alterations of montmorillonite or illite in the Permian strata by heat and aqueous solutions from the dolerite.

Glauconite

Walker (1953) mapped a section through the Permian at Ray's Hill, St. Marys, and the topmost bed of this section was found to be a glauconitic sandstone containing up to about 20 per cent glauconite in the common rounded grains with microcrystalline texture and green colour.

Brill working at Elephant Pass, also near St. Marys, identified glauconite in a sandstone from the Permian section there although here the glauconite amounted to less than 20 per cent of the rock. He correlated this bed with the Risdon Sandstone member of the Ferntree Mudstone at the locality between Mts. Peter and Paul near Friendly Beaches. The Risdon of this area contains scattered grains of glauconite but its stratigraphic position can be definitely established from the succession. No means were previously available to correlate the St. Marys section to the Permian rocks of south-eastern Tasmania.

Acknowledgments

The authors wish to gratefully acknowledge the kindness of Dr. R. E. Grim, University of Illinois, for carrying out the clay mineral determinations and his suggestions concerning the genesis of the minerals.

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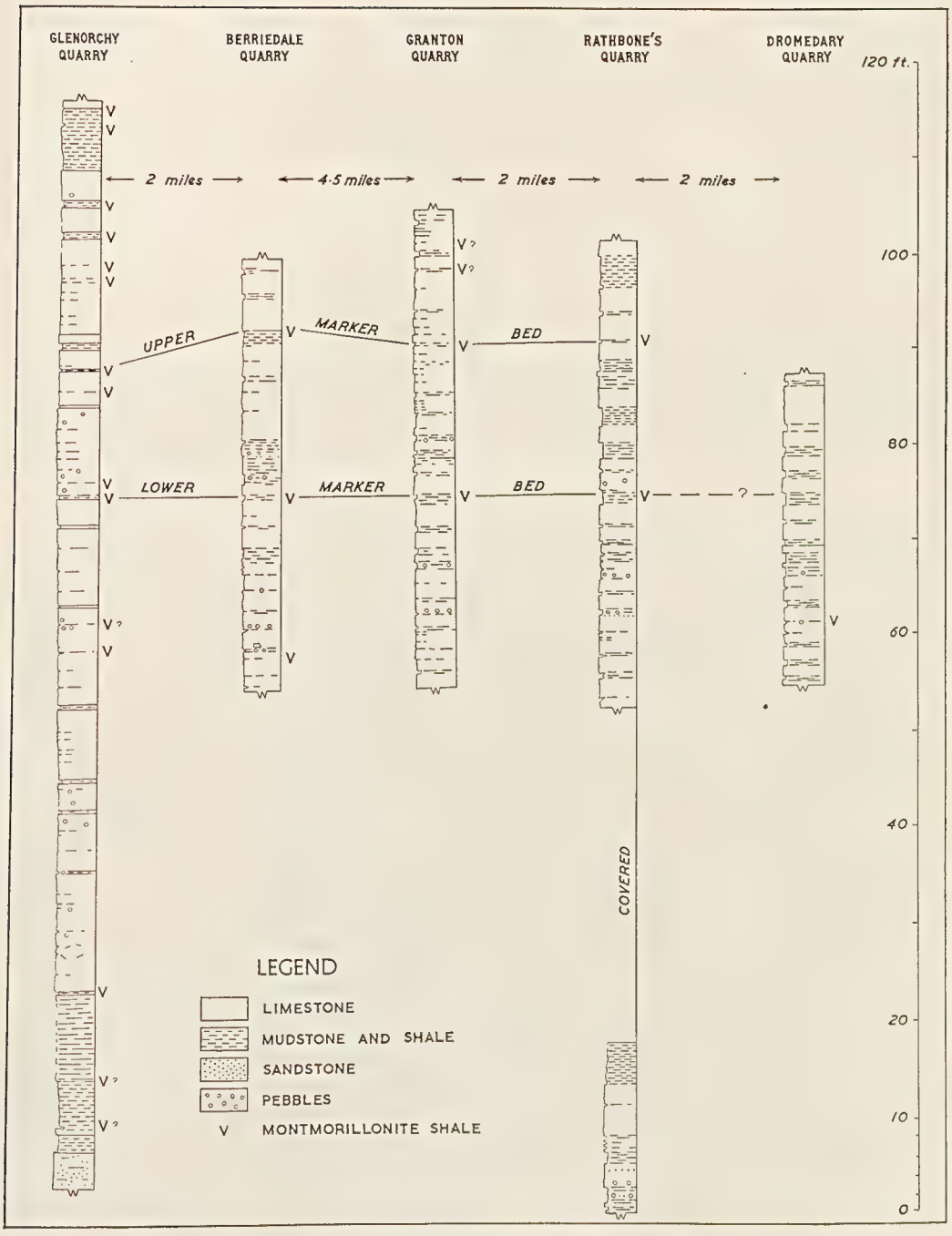
Locality Index

	Internat. Grid. Reference K/55 Quadrangle	S.Lat.	E.Long.
Dromedary	Brighton 75	42° 44′	147° 10′
Elephant Pass	St. Marys 49	41° 39′	148° 15′
Friendly Beaches	Swansea 63	42° 3′	148° 17′
Glenorchy Quarry	Hobart 82	42° 51′	147° 15′
Grange Quarry	Hobart 82	42° 56′	147° 20′
Granton	Hobart 82	42° 45′	147° 14′
Judbury	Styx 81	43° 00′	146° 56′
Little Denison River	Styx 81	43° 00′	146° 18′
Maria Island	Maria 77	42° 37′	148° 6′
Mt. Paul	Swansea 63	42° 3′	148° 15′
Mt. Peter	Swansea 63	42° 2′	148° 15′
Ray's Hill	St. Marys 49	41° 32′	148° 12′
Russell River	Styx 81	42° 59′	146° 19′
St. Marys	St. Marys 49	41° 35′	148° 12′



CORRELATION OF MONTMORILLONITE SHALE BEDS IN BERRIEDALE LIMESTONE, DERWENT VALLEY

Ordovician Corals from Ida Bay, Queenstown and Zeehan, Tasmania

By

Dorothy Hill

University of Queensland

(with 3 plates)

Abstract

Tasmanian Ordovician coral faunas appear to lie within the range Blackriveran—Richmondian of the N. American succession. Species, mostly new, are described and illustrated belonging to the genera *Streptelasma, Tryplasma, Lichenaria, Tetradium, Billingsaria, Nyctopora, Lyopora, Protaraea, Coccoseris, Acidolites, Propora, Plasmoporella* and *Eofletcheria.*

Core No. 2 Oceana Mine, Zeehan: This 964 feet core was obtained from a borehole dipping at 74° in a direction of N.52°W. The cores did not show good bedding, but angles of 35°, 25°, 19° and 19° with the axis of the core were obtained from samples 31 (215′), 42 (252′ 6″), 85 (875′ 6″) and 93 (914′ 6″) from which it was deduced that the true thickness of the beds was between 300 and 500 feet; for general argument 400 feet is assumed. The core is of blue-grey to black impure limestone with grey-black argillaceous bands; gastropods occur throughout, but are relatively richest in two bands, one between 130 and 170 feet in the core, the other between 774 and 786 feet; a brachiopod band occurs between 890 and 918 feet, and *Receptaculites* at 682 feet. There is a rich coral zone between 47 and 102 feet in the core, possibly representing 44 feet true thickness of strata; this contains *Tryplasma cerioides* sp. nov., *?Lichenaria* sp., *Tetradium* sp., *T. ?compactum* sp. nov., *?Billingsaria ?banksi* sp. nov., *Nyctopora zeehanensis* sp. nov., *?Nyctopora* sp., *Lypora* cf. *favosa* (M'Coy), and *Eofletcheria contigua* sp. nov. Of the genera represented, on present records *Lichenaria, Tetradium, Billingsaria* and *Eofletcheria* first appeared in N. America in Chazy strata, *Nyctopora* first appeared in N. America in Black R. strata, as did *Tryplasma* (if this is congeneric as I suspect with *Foerstephyllum* Bassler). *Lyopora* in N. America is confined to Trenton strata, and *Lichenaria* does not occur later than Trenton. In Great Britain *Lyopora* and *Billingsaria* are known only from the Criaghead Limestone. In Norway the earliest *Tryplasma, Eofletcheria* and *Lyopora* so far known are from the Encrinite Limestone, and the earliest *Nyctopora* from the Mjøsa Limestone, but *Lyopora* and *Nyctopora* continue into 5a beds at Stord. In N.S.W., *Tetradium, Billingsaria Nyctopora, Coccoseris* and *Propora* occur in strata overlain by beds with the *Nemagraptus gracilis* fauna.

The equivalence of the above-mentioned strata to the standard graptolite sequence would appear to be (Hill, 1951), Chazy = pre-*Nemagraptus gracilis* zone (but possibly of this zone); Black R = *N. gracilis* zone; Trenton = zones above *N. gracilis* to and including *Pleurograptus linearis* though possibly basal Trenton beds may be within the *N. gracilis* zone; Richmondian = *D. anceps* zone; Craighead Limestone = ?*Climacograptus peltifer* zone; Encrinite Limestone = *D. clingani* zone; 5a = *D. anceps* zone.

Ordovician coral faunas are perhaps as yet insufficiently known for sure correlation work, but it would seem that the horizon of the Oceana coral zone is more likely to fall within the limits of the Trentonian (top of *Nemagraptus gracilis* zone to top of *P. linearis* zone) than within the Chazy, Black R or Richmondian, and is possibly low in the Trentonian.

In the beds below the Coral Zone, only *Tetradium* spp. and *Lichenaria ramosa* are known, and these are most likely to be Trenton or pre-Trenton; the beds below the Coral Zone possibly represent 300-350 feet true thickness of strata. Following are the identifications of corals for the Oceana Bore, the figure given being depth in the core:—

Feet.	
47—102	Coral zone—*T. cerioides*, ?*Lichenaria* sp., *Tetradium* ?*compactum*, *T. sp.*, *Nyctopora zeehanensis*, *N.* sp., *Billingsaria* ?*banksi*, *Lyopora* cf. *favosa*, *Eofletcheria contigua*
143—149	*T. dendroides*
169½–170	*Tetradium*
199—215	*T. dendroides*
215—221	*T. compactum*
225	*T. dendroides*
245—249	*T. compactum*
251	*T.* ?*tasmaniense*
379	*T. compactum*
449—502	*T. petaliforme*
507	*Tetradium* sp.
578	*Lichenaria ramosa*
599	*L. ramosa*
692	*Receptaculites*
746—750	*L. ramosa*
750	*Tetradium*
774—775	*L. ramosa*
776—796	Dark argillaceous limestone with many gastropods and 784—786 *L. ramosa*
875—886	*L. ramosa*
890—918	Brachiopod band
922—923	*L. ramosa*
937—938	?*Tetradium*

Smelter's Quarry, Zeehan: Melbourne University collection herefrom contains *Tetradium dendroides* (very numerous), *T. tasmaniensis* (1 specimen, MUGD 2132), *T. conjugatum* (MUGD 2130), ?*Lichenaria* ?*ramosa* (MUGD 2256, 218, 228), ?*Nyctopora* sp. (MUGD 2131) and ?*Protaraea* sp. (197-199). *T. tasmaniense* Chapman was originally des-

cribed from the limestone on the Smelters-road, opposite the smelting works. This fauna differs from that of the Oceana Coral Zone only in its relative poverty in species and the presence of doubtful *Protaraea,* no heliolitids being observed in the Oceana fauna. In N. America *Protaraea* is not known from beds older than Trenton. The age indicated is probably Trenton.

Smelter's Quarry, Queenstown: Melbourne University collection of corals from this quarry consists entirely of *Tetradium* spp. The commonest is *T. tasmaniense* Chapman; others are *T. conjugatum, T. dendroides* and *?T.* sp. cf. *syringoporoides.* Previously described from the old Flux Quarry, now disused, at the northern end of Queenstown on the western side of the Strahan road, before it climbs out of the valley of the Queen R. half a mile N. of the railway crossing, are *Tetradium tasmaniense, Alveolites,* sp., *Protaraea* cf. *richmondense* Foerste and *Acidolites* sp. These were considered (Hill and Edwards, 1941, p. 230) Trentonian or Richmondian. All the material from Queenstown is very badly preserved, so that identification is hazardous. The limestone here is some 400 feet thick.

Bubb's Hill: Loc. 15 near H.E.C. Tower 287, Victoria Pass, Lyell Highway, Tasmania. Here *Eofletcheria ida, Nyctopora* sp. and *Plasmoporella* sp. occur. These indicate an Ordovician horizon, possibly Upper Ordovician, since *Plasmoporella* is not known elsewhere older than F_1 in the Baltic countries and *Nyctopora,* though dominantly Middle Ordovician, occurs in 5a in Norway, but is unknown in Silurian beds.

Near Ida (Wheelbarrow) Bay, a small indentation in the S.E. Tasmanian coastline in the Hastings district, a fauna very like that of the coral zone of the Oceana core occurs, but contains also solitary Rugosa and heliolitids. We have *Streptelasma* sp. cf. *aequisulcatum* (M'Coy), *Tryplasma cerioides, Lichenaria ramosa, Tetradium ?compactum, Tetradium* sp., *Billingsaria banksi, Eofletcheria ida* sp. nov., *Coccoseris ramosa* sp. nov., and *Acidolites* sp. These corals were not collected zonally over the section, and probably more than one horizon is represented. The occurrence of a different species of *Eofletcheria* suggests that although Ida Bay has two species in common with the Oceana No. 2 coral zone, a slightly different horizon may be represented. The oldest *Coccoseris* so far known is from the Cliefden Caves Limestone of New South Wales (*N. gracilis* zone) in which *Billingsaria banksi* occurs; *Acidolites* elsewhere is Upper Ordovician. The *Streptelasma* is quite like that from the Robeston Wathen (= *C. wilsoni* and *D. clingani* zones) and Coniston Limestones of Great Britain, and those from the *Cyclocrinus* Beds (possibly *C. wilsoni* zone) of Norway. The age of the Ida Bay fauna therefore seems to be at oldest Blackriveran, but probably lies between that and Richmondian.

The King Mine Core No. 13 at Zeehan has only *Aulopora* sp. as an identifiable coral. This occurs between 530 feet 6 inches and 532 feet, is not known elsewhere and cannot be considered to indicate any particular age for its stratum since *Aulopora* extends from the Ordovician into the Upper Devonian.

Systematic Descriptions

Where ordinal, family, subfamily or generic diagnoses are not given the reader should consult Hill, D, 1951 " The Ordovician Corals ". *Proc. Roy. Soc. Qld.,* LXII, pp. 1-27. Where type species of genera are not cited reference should be made to Lang, W. D., Smith, S. and Thomas, H. D., 1940. Index of Palaeozoic Coral Genera. British Museum (Natural History), pp. i-vii, 1-231.

Order: **RUGOSA** Edwards and Haime, 1850

Sub-order: **Streptelasmatina** Wedekind, 1927 (as Streptelasmacea)

Family: **STREPTELASMATIDAE** Nicholson, 1889 (as Streptelasmidae)

Genus: *Streptelasma* Hall, 1847

Streptelasma sp. cf. *aequisulcatum* (M'Coy) (Pl. III, fig. 35)

* MUGD 2126 from Ida Bay is a fragment of a solitary coral with considerable patches of recrystallisation; at a diameter of 18 mm. there are at least 35 major and 35 minor septa so dilated as to be contiguous in the minor septal zone about 3 mm. wide; the thick major septa extend unequally into the tabularium, most but a little way, some few a considerable way, some running together in groups of two or three, and many with thickened paliform lobes axially. The arrangement of these axial ends is not clearly seen, but is comparable with that in *S. aequisulcatum* (M'Coy, 1850; 1851, p. 39, pl. 1B, figs. 23, 24) from the Coniston Limestone of England, which is either of the zone of *Pleurograptus linearis* or the zone of *Dicellograptus anceps*. The specimen is very like *S.* sp. cf. *aequisulcatum* M'Coy (Sedgwick Museum A8510d) from the Robeston Wathen Limestones of Wales, which is possibly of the *Climacograptus peltifer* zone, though probably of either the *C. wilsoni* or the *D. clingani* zone.

Sub-order: **Cystiphyllina** Nicholson, 1889 (as Group Cystiphylloidea)

Family: **TRYPLASMATIDAE** Etheridge, 1907 (as Tryplasmidae)

Genus: *Tryplasma* Lonsdale, 1845

Tryplasma cerioides sp. nov. (Pl. I, figs. 1a, b, Pl. III, fig. 36)

Holotype: MUGD2123, Ida Bay, Tasmania.

Diagnosis: Cerioid or partly phaceloid *Tryplasma* with peripheral increase; corallites up to 9 mm. in diagonal diameter, with numerous short, subequal septa.

Description: The corallum is cerioid in part but phaceloid in peripheral regions; new corallites arise inside the calice, around the periphery. There is considerable variation in size of corallite, the largest observed being 8 and 9 mm. in diagonal diameters. There is a narrow peripheral stereozone about 0·25 mm. wide, within which the neighbouring septa are contiguous and each is a continuous vertical plate; but inside this zone, the axial edge of each septum is acanthine, the trabeculae being in single vertical series and extending almost horizontally inwards for a maximum observed distance of 1 mm. In a corallite of 8 mm. diagonal diameter there are 38 septa which are not divisible into alternate orders of longer and shorter (major and minor) septa; the septa of neighbouring corallites are opposite or sub-opposite. There are no dissepiments and the tabulae are complete and moderately arched.

* MU = Melbourne University Collection.

The species is common at Ida Bay, and here the tendency for cylindrical groups of buds to grow freely up from cerioid regions of the corallum is very marked.

Two good specimens occur in the Oceana No. 2 Core in sample 7 at 62 feet to 62 feet 6 inches and in sample 8 (62 feet 6 inches to 63 feet, Pl. I, fig. 1). Corallites doubtfully referred to the species (doubtfully because their stereozones and septa are longer) are present in sample 3 from Oceana No. 2 Core at 47 to 48 feet.

Two cerioid species have recently been described (Hill, 1953) from the Middle Ordovician ($4\beta\delta$) Encrinite Limestone of Skien District, Norway, and their possible generic identity with *Foerstephyllum* Bassler (1950, p. 269) indicated, depending on which of the syntypes of *Columnaria? halli* Nicholson, 1879 is designated as lectotype of this species, which is the type species of *Foerstephyllum*. Our Australian species is not unlike specimens referred to *C. halli* from the Black R. and Trenton of U.S.A.

Order: **Tabulata** Edwards and Haime, 1850

Family: **CHAETETIDAE** Edwards and Haime, 1850

Sub-family: **Lichenariinae** Okulitch, 1936 (as Lichenaridae)

Genus: *Lichenaria* Winchell and Schuchert, 1895

Lichenaria is very common in the Chazy, Black R. and Trenton of North America, and Bassler (1950) has referred two species from the Canadian to the genus. The Tasmanian species described below is the first known from outside N. America.

Lichenaria ramosa sp. nov. (Pl. I, figs. 14, 15, pl. III, fig. 37)

Holotype: UT 23503 from sample 85 at 875 feet 6 inches down in Core No. 2, Oceana Mine, Zeehan, Tasmania, in the Smelter's Limestone. Other specimens occur in this core over the range 578 feet down to 923 feet 6 inches.

Diagnosis: Rather slenderly branching coralla with 3 to 4 polygonal corallites in 1 mm., numerous tabulae, no septa and no mural pores.

Description: The corallum is ramose, the branches being cylindrical or a little flattened, 5 to 10 mm. across, and not regular in direction. The corallites diverge from the axis, slowly at first but with gradually increasing curvature, the calices opening almost at right angles. New corallites appear at the angles of the old, and are at first of very small diameter, but grow to average size in quite short distances. The corallites are 4 to 6-sided each side being reasonably straight. The walls are a little thickened but show no septa, septal spines or mural pores. The tabulae are numerous, complete, flat and distant except in a zone up to 1 mm. wide at the surface of the branch, where they are close and incomplete, successive tabellae inosculating off-centre. The calices are very deep in unweathered specimens, the walls projecting 0·5 mm. above the topmost tabula.

The small size of the corallites raises doubts whether the species might be polyzoan, but the absence of acanthopores, or of any other evidence of dimorphism, the absence of moniliform wall thickenings and the presence of numerous tabulae support reference to the Tabulata. It differs from N. American species of *Lichenaria* in its ramose habit and small size of corallite. Several specimens have been collected from Ida Bay.

Sub-family: **Tetradiinae** Nicholson, 1879

The possibility that the Tetradiinae may be calcareous algae seems to me to deserve serious investigation.

Genus: *Tetradium Dana*, 1848

Bassler (1950, pp. 279-292) has reviewed the N. American species of *Tetradium*. His work indicates that average corallite diameter is constant in a species, if one takes as average diameter that where the septa extend from half to two thirds of the distance to the centre. Also that the growth form of the corallum is not in general a safe indication of stratigraphic horizon. Thus N. American species may be divided into four groups, according to growth form:—

(1) *T. syringoporoides* group, with coralla consisting of single corallites dividing at long intervals into four tubes which separate and continue as separate individuals until division occurs again;

(2) *T. cellulosum* group, with single corallites dividing less slowly at more or less regular intervals into separate bundles each of 4 to 16 or more closely adhering corallites;

(3) *T. halysitoides* group, where increase is so rapid that chains or networks enclosing empty spaces result;

(4) *T. fibratum* group, with massive (cerioid) coralla in which the corallites reproduce so quickly that they remain in contact throughout their length. Representatives of all four groups may be found over the range Black River to Richmondian.

In Oceana Core No. 2, Zeehan, *Tetradium* occurs somewhat rarely from 57′ 6″ to 143′ 6″, is relatively common between 149 and 750 feet, but is apparently absent in the shelly limestones from 750 feet to the bottom of the core at 964′ 6″.

Tetradium petaliforme sp. nov. (Pl. I, fig. 10).

Holotype: UT 23513 from sample 50 at 449 feet down in Core No. 2 Oceana, Zeehan, from the Smelter's limestone. Other coralla occur in the same core in samples 51 (501 feet) and 52 (502 feet).

Diagnosis: Massive *Tetradium* with large, very thin walled corallites typically 8 sided and 1·5 mm. in diameter.

Description: The external form of the corallum is either cerioid (massive without lacunae) or, more likely, with thick chains or networks of corallites enclosing empty spaces; the uncertainty is because the species is known so far only from 7/8 inch cores. The corallites are very thin walled; they are arranged in sub-parallel rows such that those of neighbouring rows are sub-opposite; the edges of the otherwise four-sided prisms are bevelled, and often also the four sides are bent inwards in their mid-lines, so that a four-petalled Tudor-rose pattern is obtained in transverse section. The dividing walls of new corallites proceed inwards from the mid-lines of the four main faces; when they extend from $\frac{1}{2}$ to $\frac{2}{3}$ across the radius, the smaller diameter of the corallite is approximately 1·5 mm. Tabulae are rare to absent.

Remarks: In the holotype, the corallites show a greater diameter in one direction, usually 1·8 mm. against 1·5 mm; this may be due to distortion or perhaps to obliquity of section.

Tetradium tasmaniense Chapman (Pl. II, figs. 17, 23, 24)

Tetradium tasmaniense Chapman, 1919, p. 8, pp. 1-3

Type material: Of the type material, from the Smelter's Road, Zeehan, only two thin sections used by Chapman for his figs. 1-2, have been located, 13138-9 in the Nat. Mus. Melb.; some of the characters of the species are therefore in doubt. Consequently, I have examined with especial care the various species of *Tetradium* occurring in the present collections from Zeehan, though there is of course, no certainty that any of these new collections are from the same locality or even the same horizon as the type material. I have many specimens from Smelter's Quarry mostly weathered out from their containing limestone, and some fresh material embedded in limestone from Bore Core No. 2 Oceana Mine. The weathered specimens are with two exceptions branching forms in which the branches broaden distally or at least do not taper, the corallites opening at the tops of the branches and running quite parallel to one another inside the branch. One exception, MUGD 2130 is *T. conjugatum*, a species with slender tubes containing 4 corallites, of the *T. syringoporodies* type. The other, is a coarsely branching form with tapering branches, on which the corallites open all round the periphery, as well as the tip, though not at right angles to the axis.

It is thought that the thin sections Chapman illustrated must have come from a form like the last, though it is the only one of its kind in the present collections and probability would suggest that a single specimen picked up at random like the type was would be from that species most commonly represented in the surface outcrop of the limestone.

Of Chapman's thin sections one shows vertical sections through branches about 4 mm. wide from which the outer parts have been worn by weathering before burial. In these the thin-walled corallites are of roughly parallel growth, with tabulae rare to absent. The other shows what is probably a transverse section of a branch about 10 mm. in diameter, which has no enclosing boundary wall as in *T. dendroides*, but has corallites tending to present oblique or vertical sections at the circumference, though those at the axis are transverse sections. The largest corallite in which the septa are only $\frac{2}{3}$ the radius has a larger diameter of 1·25 mm. and a smaller of 1 mm.; in parts of the section, corallites of only 0·6 or 0·7 mm. shorter diameter and 1 mm. longer diameter are seen with septa extending right to the axis, so that the corallites of this species are of variable size. The walls are moderately thick, so that the inner corners are somewhat rounded. The sections tally with a branch whose corallites open outwards at the periphery, as in the single specimen MUGD 2132 (Pl. II, fig. 17) not with a branch with an enclosing wall as in the common species from Zeehan quarries. Such branches with circumferential calices are very common in the Queenstown Quarries almost to the exclusion of branches with enclosing walls.

A very similar appearance is given by a section from 251-252 feet down in Oceana No. 2 Core, Zeehan (Pl. I, fig. 11).

Some specimens from Queenstown Quarries referred to *T. tasmaniense* have corallites opening very obliquely, yet without projecting lower lips.

Tetradium compactum sp. nov. (Pl. I, fig. 12).

Holotype: UT 23517 from sample 31 (215 feet to 215 feet 6 inches) in Core No. 2 Oceana, Zeehan, Tasmania, in the Smelter's Limestone.

Diagnosis: Massive, cerioid *Tetradium* with moderately thick-walled corallites 0·8 in diameter.

Description: The total form of the colony is unknown but one 7/8 inch core passed through a corallum, at least 22 cm. long and 20 mm. tall, with a hummocky upper surface and apparently without lacunae. The corallites average 0·8 mm. diameter when the new dividing walls extend between $\frac{1}{2}$ and $\frac{2}{3}$ of the way to the centre; the new dividing walls thicken peripherally, and the main walls are rather thickened; the corallites are chiefly 4-sided, often with rather rounded corners, and arrangement in parallel rows is neither marked nor persistent. Tabulae are rare to absent. There may be a broadly marked curvature in upward direction of growth of the corallites in considerable portions of the corallum (see figure of vertical section).

Remarks: This massive species occurs in the No. 2 Oceana core at Zeehan over the section 215 to 379 feet. Of North American species it shows considerable resemblance to the Trentonian *T. fibratum* Safford, in which however the corallites are much larger. In sectioning material from Ida Bay, a fragment of a *Tetradium* colony was encountered with numerous corallites in connection by common walls and of average diameter about 0·8 mm.; this is doubtfully referred to *T. compactum* (Pl. III, fig. 38).

Tetradium dendroides sp. nov. (Pl. I, fig. 9, pl. II, figs. 16, 28).

Holotype: MUGD 2260, from Smelter's Quarry, Zeehan, Smelter's Limestone.

Diagnosis: Ramose *Tetradium* with cylindrical or flattened branches on which the calices of 0·75 mm. adult diameter, open terminally and not laterally.

Description: The corallum is branching, the branches being cylindrical or flattened, each enclosed in epitheca laterally. The cylindrical branches are up to 10 mm. in diameter, and the flattened branches to 7 mm. across. The calices open only at the tops of the branches, and before the dividing walls become complete are 0·75 to 0·8 mm. in diameter, though they may be as wide as 1·0 mm. when the dividing walls are complete. Arrangement into parallel rows in the flattened branches is imperfect. The walls are moderately thick and the angles of the corallites moderately rounded.

Remarks: This branching form, common in the Quarries at Zeehan, differs from *T. tasmaniense* in having its calices at the tips only, and not along the sides of the branches. In Oceana Core No. 2, Zeehan, it is found between 131 feet and 226 feet (in samples ?19, ?20, 25, 26, 27, 28, 29, 30 and 37). It is rare in the Queenstown Quarries.

Of the American species, this form is most closely comparable with the Blackriveran *T. cellulosum*. MUGD 2243 from the Queenstown Quarries (Pl. II, fig. 29) has a similar type of growth to *T. dendroides*, but the branches are closely spaced, almost touching, and the parallel

corallites are larger, of average diameter 1 mm. when the new dividing walls are $\frac{1}{2}$ to $\frac{2}{3}$ the radius of the old corallite. Only one branch of *T. tasmaniense* (MUGD 2132, pl. II, fig. 17) is represented in the M.U. collection from Zeehan Quarries, though there are 104 branches of *T. dendroides*.

Tetradium conjugatum sp. nov. (Pl. II, figs. 18, 25).

Holotype: MUGD 2247, Queenstown Quarries, Tasmania; Smelter's Limestone.

Diagnosis: Corallum of corallites 1 mm. in diameter united in very irregular mesh so that the lacunae occupy less space than the corallites.

Description: The corallum consists of single corallites of average diameter 1 mm. dividing at long intervals into 4 tubes, one or two of which then separate slightly from the others, but may grow to touch corallites from other divisions, so that chains occur with narrow irregular lacunae, the lacunae occupying far less space in any transverse section of the colony than the corallites; the corallite walls have rounded corners and become indented at the positions of growth of new walls. Tabulae are rare.

Other material is MU 40 from the Queenstown Quarries, and MUGD 2130 from Zeehan Quarries.

In N. America, the *T. halysitoides* group is common in Black R and Trenton strata, rare in the Richmondian.

?*Tetradium* sp. cf. *syringoporoides* Ulrich
(Pl. II, fig. 27)

MU 47–MUGD 2250, Queenstown Quarries, Tasmania, are of coralla with distant slender corallites about 1 mm. in diameter spaced on the average about 5 mm. apart. The corallites tend to be square in section, with rounded edges, but the infilling is recrystallised and no dividing walls or tabulae can be distinguished in thin section, though some corallites are seen on the weathered surface to divide into four, which diverge rather rapidly. The growth habit is thus of the *T. syringoporoides* group which is dominantly Blackriverian, though one form occurs in the Upper Chazy of Canada, and others are known in the Trenton of Central Tennessee and the Richmondian of N. Greenland.

Tetradium sp. (Pl. I, figs. 13a, b)

Three specimens were encountered in thin sections of samples from Oceana No. 2 Core, Zeehan, in which the growth form appears to be of single corallites dividing at long intervals into four tubes which separate and continue as separate individuals until division occurs again. The diameter of the adult corallites when the dividing walls extend $\frac{1}{2}$ to $\frac{2}{3}$ way to the centre, is 1·5 mm.; the walls are rather thin, and the angles of the corallites are rounded; tabulae are not seen. None are in my opinion sufficiently well preserved for nomination as a type specimen, so the species to which they belong, and which I believe to be separable from the other four Zeehan species described above is at present given no name. The specimens are from samples 62 (at 750′), 53 (507′ 6″) and 21 (169′ 6″ to 170′).

Family: **SYRINGOPHYLLIDAE.** Pocta, 1902

=Lyoporidae Kiaer, 1930; Calapoeciidae Hill, 1951.

Massive; septa short, thick, spinose and typically equal in number in any species; mural pores interseptal and arranged in horizontal rows, each row just above a tabula; coenenchyme may be formed by extensions from the tabulae and septa which intersect to enclose horizontal tubular spaces. M.Ord. — L. Sil.

Sub-family: **Billingsariinae** Hill, 1951 (=emend. Billingsaridae Okulitch, 1936)

=Nyctoporinae Hill, 1951

Coenenchyme absent or of vertical trabeculae only, septa short, typically 16, may alternate in size. M.–U.Ord.

Genus: *Billingsaria* Okulitch, 1936

Type species by original designation *Columnaria parva* Billings, 1859.

Septal trabeculae dilated wedgewise to form a thick wall; vertical trabeculae may develop at axis. M.Ord., N.Am., Aus.

I have considerable doubt whether the separation of this genus from *Nyctopora* is justifiable.

Billingsaria banksi sp. nov. (Pl. III, fig. 40).

Holotype: MUGD 2113 from Ida Bay, S.E. Tasmania.

Diagnosis: *Billingsaria* with corallites 3 in 3 mm.

Description: Corallum hemispherical. There are 3 calices in 3 mm. Each corallite possesses 8 septa each about $\frac{1}{3}$ of the radius of the corallite, and dilated wedgewise towards the periphery; most corallites also show 8 much shorter septa, alternating with the longer; the septal trabeculae are clearly visible in transverse section, one in each short septum, two or more in each longer septum and they are apparently almost vertical. Some corallites show a strong columella, consisting apparently of a single trabecula, others several disjunct trabeculae, and many, no axial structure. Tabulae are thin and rather distant.

Remarks: A very small specimen UT 23532 (Pl. 1, fig. 2) from sample 3 (47 to 48′) in Core No. 2 Oceana, Zeehan, Smelter's Limestone, encrusting a polyzoan, is referred somewhat doubtfully to this species, owing to the habit and smaller size of corallite (4 in 3 mm.).

This Tasmanian species is very similar to the N. American Chazy type species and to the Scottish Craighead (?=Trenton) *B. occidentalis* (Nich. & Eth.). The trabeculae are not tightly welded together and in thin sections where recrystallisation has occurred the spaces between them appear falsely as canals (cf. Okulitch, 1936, p. 61).

Genus *Nyctopora* Nicholson, 1879

Type species *N. billingsi* Nicholson, 1879, which was a *nom. nov.* for *Columnaria goldfussi* Nicholson 1875 (*non* Billings, 1858 from the Trenton of Peterborough, Canada.

Walls and septa relatively thin. M.–U.Ord.

Nicholson's figures of the type species (1879, pl. 9, figs. 3*a-c*) show a moderately thin and rather crenulate wall with mural pores and without regularity of septal arrangement. A thin section of a specimen in the British Museum from Nepean Pt., Ottawa, referred to *N. billingsi*, shows a horizontal row of small pores in the walls as in *Calapoecia*. Bassler (1950, p. 267) has founded *Saffordophyllum* on a species in which there are 8 septa only and these proceed from inwardly directed undulations in the thin wall; Nicholson's figure of *N. billingsi* however, suggests that it also has undulate though somewhat thicker walls. Those species with 12 septa placed by Bassler in *Saffordophyllum* and in *Nyctopora* (*Proheliolites*) should, it seems to me, be transferred to the family Heliolitidae, genus *Proheliolites*.

Nyctopora zeehanensis, sp. nov. (Pl. I, figs. 3*a*, *b*)

Holotype: UT 23531 from sample 11 at 91 feet in Core No. 2 Oceana Mine, Zeehan, in Smelter's Limestone.

Diagnosis: Corallum massive with corallites 1·25 mm. in diameter with rather thin, crenulate walls; septa unequally developed from corallite to corallite but in parts of some eight longer alternate with eight shorter, each rising from an inwardly projecting crenulation.

Description: The corallum is large and cerioid, with corallites 1·25 mm. in average adult diameter and five or six-sided. The common walls are moderately thin with vertical waves; septa project from the inwardly projecting crests; septal development is imperfect, or unequal from corallite to corallite; the maximum development would appear to be 16, 8 longer and 8 shorter, but sections of few corallites show this perfectly; some show no septa; others show a few longer septa with perhaps a few shorter alternating; the waves in the wall are likewise not regularly or equally developed. The septa appear trabeculate. No mural pores have been observed, and the tabulae are thin, almost horizontal and rather close.

Remarks: Except for the absence of mural pores, this species resembles very closely the thin sections of the syntype of the type species figured by Nicholson (1879, pl. 9, figs. 3*a-c*) from the Trenton of Peterborough, Canada.

Nyctopora sp. (Pl. II, fig. 30)

One small domed fragment from Loc. 15, near H.E.C. Tower, 287, Bubb's Hill, Victoria Pass, Lyell Highway, Tasmania has corallites 1 mm. in average diameter, with 8 very short major and 8 minor septa each of vertical trabeculae, and rather distant flat tabulae. The occurrence of this typically Ordovician genus sufficiently determines the age of the Bubb's Hill fauna as Middle or Upper Ordovician though the material is insufficient for detailed description.

?*Nyctopora* sp. (Pl. I, fig. 4)

Material: One fragment UT 23530 from sample 14 (94 feet 6 inches to 95 feet), from Core No. 2, Oceana Mine, Zeehan.

Description: The corallum, known only from a fragment intersected in a bore core is either ramose or tumulose, since in a vertical section the corallites curve outwards from an axial region to open somewhat obliquely

at the calices, opposite calical faces on the branch or tall tumulus being 15 mm. distant. The corallites are prismatic, usually five or six-sided, the average adult diameter being about 1 mm. Recrystallisaton leaves one uncertain whether the common walls are thick or not; in some parts of the transverse section of the corallum one may consider trabeculae distinguishable in the walls, almost vertical, like those of *Billingsaria;* in others, outgrowths from the walls appear to be secondary calcite, dark in colour but not so dark as the actual wall tissue. Because of this doubt, I am uncertain whether *Nyctopora* or *Lichenaria* is the correct generic reference, but I incline to the view that separate trabeculae are present as in the Billingsariinae and therefore place the fragment doubtfully in *Nyctopora.* No mural pores are present in either of the sections prepared. In vertical section, the walls appear a little thickened, and many of the tabulae show a sudden axial uparching.

Sub-family: **Syringophyllinae.**

=Calapoeciinae Hill, 1951.

Cerioid or with coenenchyme; septa 20 to 24, equal. M.Ord.-Sil.

Genus: *Lyopora* Nicholson & Etheridge, 1878

=*Liopora* Lang, Smith & Thomas, 1940, *non* Girty, 1915.

Type species: *Palaeopora*? *favosa* M'Coy, 1850, p. 285, described and figured as *Palaeopora favosa* M'Coy, 1851, p. 15, pl. 1C, fig. c, 3*a-d*, from the Ordovician limestone and shale of Craighead, Girvan, Ayrshire, Scotland. The Middle Ordovician Craighead Limestone is possibly of the *Climacograptus peltifer* zone.

Massive coralla with polygonal corallites in which each corallite has a single peripheral ring of ?20 vertical series of slightly inclined thick trabeculae, those of neighbouring corallites alternating or opposed; the thick double walls so formed may be pierced in horizontal zones by a row of irregular rounded pores, each caused by a local thinning of the trabeculae; the tabulae are distant and slightly sagging.

The genus is known from the *Climacograptus peltifer* zone in Scotland (Craighead) and Kalstad, Mjϕsa and Encrinite Limestones (4β) in Norway and the Trenton (Jacksonburg Limestone) of New York, U.S.A. The known range is thus between the *C. peltifer* and *Dicranograptus clingani* zones inclusive.

Lyopora cf. *favosa* (M'Coy) (Pl. I, fig. 5)

Material: One fragment UT 23537 in sample 6 (58 feet to 58 feet 6 inches) in Core No. 2, Oceana Mine, Zeehan, Tasmania, Smelter's Limestone.

This small fragment differs in no essential particular from the type species especially as it is developed in Norway; the common walls between corallites are on the average 1 mm. thick, the free space in the corallite 1·3 mm. wide, thus slightly smaller than in the Norwegian and Scottish examples. The trabeculate septa are distinguishable, in transverse section, but no information on inclination of the trabeculae is available from the vertical section owing to recrystallisation. Vacuities in the wall are in somewhat irregular horizontal rows. The tabulae are thin, sagging and distant. Detailed description of the Scottish (Cox, 1936) and Norwegian (Hill, 1953) specimens should be consulted.

Family: **HELIOLITIDAE** Lindström, 1873 (as Heliolithidae)

Massive coralla with slender tabularia separated by coenenchyme; each tabularium with twelve equal spinose septa and with complete tabulae. M.Ord.–U.Dev.

Sub-family: **Coccoseridinae** Kiaer, 1899

Encrusting, discoid, nodular or branching; coenenchyme tubular; trabeculae greatly thickened; septal trabeculae curving upwards and inwards to become vertical in axial parts of tabularia; coenenchymal trabeculae vertical, spaced so as to form vertical tubules. M.Ord.–L.Sil.

Coccoseris ramosa sp. nov. (Pl. III, fig. 41)

Holotype: MUGD 2119, Ida Bay, S.E. Tasmania.

Diagnosis: Branching coralla with small tabularia about 1 mm. apart; septal, axial and coenenchymal trabeculae so stout as to fill all spaces. M.Ord.–L.Sil.

Description: The corallum is branching, the branches being 12 to 15 mm. in diameter. The 12-septate tabularia diverge from axis to periphery of branch, and each is about 1 to 1·5 mm. in diameter, with the septa forming a collar about the axial trabeculae which form a plug about 0·5 mm. wide, no free space occurring anywhere in the tabularia; each tabularium is separated from its neighbour by vertical coenenchymal trabeculae; the septal trabeculae curve upwards and inwards, all so dilated as to leave no intervening spaces.

The European species are from $4\beta\delta$ and $5a$. This Tasmanian species has rather a narrow coenenchyme, perhaps narrow enough for it to be better placed in the middle and upper Ordovician *Protarea*. The two genera seem to merge and should, perhaps, be united.

Genus: *Acidolites* Lang, Smith and Thomas, 1940

Coenenchyme wide, trabeculae relatively slender, leaving spaces crossed by dissepiments. U.Ord.–L. Sil.

Acidolites sp. (Pl. III, figs. 42, 43)

MUGD 2120 from Ida Bay is from a thin blister-like lamellar corallum, from which only one section, a transverse section, was obtainable. The tabularia are 1 to 1·25 mm. in diameter, and are distant from one another also 1 to 1·25 mm.; each has twelve short equal septa in general discontinuous with the vertical trabeculae of the wide axial or columellar zone; the tubules of the coenenchyme are small, with walls as thick as the septa, but not so thick as to fill the tubules. No truly vertical section being possible, the nature of the transverse skeletal elements is not known.

The specimen is very likely conspecific with the very poorly preserved *Acidolites* sp. (Hill & Edwards, 1941, pl. vii, figs. 3*a*, *b*), from the old flux quarry, N. end of Queenstown, W. of the Strahan Road, half a mile from the railway station, though the Queenstown specimen has tabularia not more than 1 mm. in diameter.

MUGD 2114 from Ida Bay has tabularia of 1 mm. diameter, but these are more closely spaced than in MU 309 or the Queenstown form

and the coenenchyme is coarser; also the axial trabeculae are few, and the tabulae are thin, numerous and gently depressed, and I am uncertain whether it is conspecific.

Sub-family: **Plasmoporinae** Sardeson, 1896

=Proporinae Hill, 1951

Coenenchyme of domed plates and isolated trabeculae, or with trabeculae uniting to form discontinuously walled tubuli. M.Ord.–U.Sil.

Genus: *Propora* Edwards & Haime, 1850

Coenenchyme of domed plates and isolated trabeculae not more thickened in surface zones than in inner or axial zones of the corallum. Tabulae flat or sagging. M.Ord.–U.Sil.

Propora sp. cf. *hirsuta* Lindström (Pl. II, fig. 22)

An unnumbered specimen, almost certainly from one of three localities, Smelter's Quarry, Zeehan, Smelter's Quarry Queenstown, or Bubb's Hill, is very close indeed to *P. hirsuta* Lindström (1899, p. 64) from the Upper Ordovician F_1 of the Baltic countries and from the Middle Ordovician Robeston Wathen Limestone of Wales.

The tabularia are about 2 mm. in diameter, and may be contiguous or up to 1 mm. distant from their neighbours; the walls of the tabularia are angulate, projecting outwards between the 12 equal septa and inwards at the septa; the angular projections into the coenenchyme may be lengthened by vertical trabeculae; discrete vertical trabeculae may also occur in the coenenchyme, but no tubes are found; the septa are spinose, the spines being long and curving upwards and inwards to the axis, so that they appear as separate dots in transverse section. The tabulae are thin and may be arched upwards by the septal spines; dissepiments occur in the narrow coenenchyme, with discontinuous vertical trabeculae.

Probably Kiaer (1899) was right in regarding this species as of a genus distinct from *Heliolites* and *Propora*, but the name he chose—*Nicholsonia*—was preoccupied. Until the type specimens of M'Coy's species *Porites megastoma* are re-investigated it seems wise to refer our species to *Propora*, noting that it is not known to range into the Silurian.

Genus: *Plasmoporella* Kiaer, 1897, 1899

Like *Propora* but with domed and complete or incomplete, tabulae septa projecting into coenenchyme and slender trabeculae. U.Ord.–M.Sil.

Plasmoporella sp. (Pl. II, figs. 31, 32)

The specimens from Bubb's Hill, may well be conspecific with the form described by Hill (1942, p. 10, pl. 2, figs. 10*a*, *b*) from the limestone at the head of the Nelson R. It has the same closely packed, very fine tissue, with the tabulae replaced by numerous small tabellae; the dissepiments and tabellae appear rather taller domes than in the Nelson R. specimen.

Family: AULOPORIDAE Edwards and Haime, 1850

=Syringoporiens de Fromentel, 1864; Syringoporidae Hill, 1951.

Genus: *Aulopora* Goldfuss, 1829

Type species (designated by Edwards and Haime, 1850, pl. xxvi) *A. serpens* Goldfuss, 1829, p. 82, pl. xxix, figs. 1*a-d*, M.Dev., Bensberg & Eifel district, Germany.

Reptant coralla, corallites with thick walls and with calices opening upwards from prostrate conico-cylindrical proximal parts, each corallite arising through the lower calical wall of its predecessor. Tabulae present or absent. Ord.–Dev.

Aulopora sp. (Pl. II, fig. 34)

Material: UT 23538-9 from samples 145 and 146 (530 feet 6 inches to 532 feet) in Core No. 13, King Mine, Zeehan.

The sections show the corallum to be encrusting a polyzoan, with the slender, cylindrical, proximal parts of all corallites reptant, their calical portions turning to open with tall sides at right angles to the reptant parts. The calical parts may be 2·5 mm. to 3 mm. in diameter, and 4 or 5 mm. apart; they may extend 4 or 5 mm. above the substratum. The reptant parts are 1 to 2 mm. in diameter. The wall is relatively thin, about 0·25 mm. and the tabulae are incomplete, numerous and very thin. Septal spines are not observed. The base of the upright part of the corallite is filled with thin vesicular tissue.

This species of *Aulopora* was not observed in the Oceana No. 2 Core, nor anywhere else in the Zeehan district. Further specimens are required for full understanding. It is not necessarily Ordovician.

Genus: *Eofletcheria* Bassler, 1950

Genotype: (by original designation): *Columnaria incerta* Billings, 1859, p. 428; Mingan I., Gulf of St. Lawrence, N. America. Chazy, M.Ord.

Bushy colonies of slender cylindrical corallites; increase lateral and frequent, offsets diverging immediately or at first parallel to and in contact with parents, so that small sections of the corallum may be cerioid with two or three rows of two or three corallites in contact for some short distance, or so that a halysitoid chain may form temporarily; corallites with a moderately wide peripheral stereozone consisting of crowded, short, thick, monacanthine trabeculae in vertical series in contact laterally; the inner thin ends of the trabeculae sometimes project free from the stereozone; tabulae typically rare, horizontal, sagging or with a median notch, sometimes incomplete. No perforations through the walls in cerioid portions. M. & U. Ord., N. America, Scandinavia and Tasmania.

I have recently discussed the Norwegian species of this genus (Hill, 1953, p. 154).

Eofletcheria contigua sp. nov. (Pl. I, figs. 6, 7)

Holotype: UT 23527 from Core No. 2 Oceana Mine (believed to be from a level about 92 feet 6 inches) Zeehan; Smelter's Limestone.

Diagnosis: Corallites of average diameter 1 mm. grouped in cylindrical stems up to 9 mm. in diameter, and therein growing back to back, each proceeding vertically for some distance before curving outwards.

Description: The corallum is branching, the corallites being not very regularly grouped in roughly cylindrical stems up to 8 or 9 mm. in diameter; the corallites are of average diameter about 1 mm. and run more or less vertically in the axial parts of the branch where they are contiguous and prismatic, then curve to open obliquely; their calical parts may be free and cylindrical. No mural pores are observed in the cerioid parts. The thickness of the wall in each corallite may be 0·25 mm. so that common walls may be as much as 0·5 mm.; the cylindrical calical rims are thinner. The wall tissue is recrystallised and trabeculae are therefore not distinguishable. Tabulae are rare, very distant and domed. Polyzoa are sometimes seen occupying the spaces between the cylindrical calices.

Remarks: This species in its growth form is very similar to a specimen from the Encrinite Limestone of the quarry of Versvik, Norway, referred doubtfully to *E. irregularis* Hill (1953, p. 156, pl. 2, fig. 13).

Eofletcheria ida sp. nov. (Pl. II, fig. 33; Pl. III, fig. 44)

Holotype: MUGD 2128, Ida Bay, Tasmania. Other material, MU 300 = 292 also from Ida Bay.

Diagnosis: Corallum of erect branches 3 to 4 mm. in diameter, with three to four corallites 1·5 to 2 mm. in diameter back to back, growing vertically for 5 or 6 mm. before opening outwards.

Description: The corallum is branching, and it has not been ascertained whether the branches proceed from a reptant base or not. The branches are 3 or 4 mm. in diameter and in them the corallites grow vertically for a short distance, 5 or 6 mm., before turning rather sharply to open nearly at right angles, the calices projecting up to 2 mm. The corallites are 1·5 to 2 mm. in diameter, with a wall up to 0·5 mm. thick, though usually somewhat less. Neither septal spines nor mural pores, have been observed, and tabulae are very rare or may indeed be absent, most corallites containing nothing but muddy matrix inside the thick walls.

Remarks: This species differs from that of the coral zone of the Oceana No. 2 Core of Zeehan in its coarser corallites and slender branches, though the growth form is similar.

Several specimens from Bubb's Hill near H.E.C. Tower 287, Victoria Pass, Lyell Highway seem conspecific with the holotype.

Acknowledgments

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EXPLANATION OF PLATES

All figures are photographs of thin sections x1·8 diameter approximately except where otherwise indicated.

PLATE I

Corals from the Coral Zone between 47 feet and 102 feet in Core No. 2, Oceana Mine, Zeehan, Tasmania. ?Trentonian.

FIG. 1*a*, *b*.—*Tryplasma cerioides* sp. nov. UT 23502 from sample 8 (62 feet 6 inches to 63 feet); *a*, transverse; *b*, vertical.

FIG. 2.—*Billingsaria ?banksi* sp. nov. UT 23532 from sample 3 (47 feet to 48 feet); transverse, showing coralline algae.

FIG. 3.—*Nyctopora zeehanensis* sp nov. Holotype. UT 23531 from sample 11 (91 feet); *a*, transverse; *b*, vertical.

FIG. 4.—?*Nyctopora* sp. UT 23530 from sample 14 (94 feet 6 inches to 95 feet); *a*, transverse; *b*, vertical.

FIG. 5.—*Lyopora* cf. *favosa* (McCoy) UT 23537 from sample 6 (58 feet to 58 feet 6 inches); *a*, transverse; *b*, vertical.

FIG. 6.—*Eofletcheria contigua* sp. nov. Holotype UT 23527 from sample 12 (92 feet 6 inches).

FIG. 7.—*E. contigua* sp. nov. UT 23533 from sample 10 (89 feet); tranverse; encrusted by polyzoan.

FIG. 8.—*Tetradium ?compactum* sp. nov. UT 23525 from sample 12 (92 feet 6 inches); transverse.

Corals from below the Coral Zone in Core No. 2, Oceana Mine, Zeehan, Tasmania (102 feet to 964 feet); ?Trentonian to ? Blackriveran.

F.G. 9.—*Tetradium dendroides* sp. nov. U.T. 23519 from sample 27 (204 feet 6 inches); transverse.

FIG. 10.—*Tetradium petaliforme* sp. nov. Holotype UT 23513 from sample 50 (449 feet); *a*, transverse; *b*, vertical.

FIG. 11.—*Tetradium ?tasmaniense* Chapman. UT 23516 from sample 41 (251 feet to 252 feet).

FIG. 12.—*Tetradium compactum* sp. nov. Holotype UT 23517 from sample 31 (215 feet to 215 feet 6 inches); *a*, transverse; *b*, vertical.

FIG. 13.—*Tetradium* sp. UT 23522 from sample 21 (169 feet 6 inches to 170 feet); *a*, transverse; *b*, vertical.

FIG. 14.—*Lichenaria ramosa* sp. nov. Holotype UT 23503 from sample 85 (875 feet 6 inches).

FIG. 15.—*L. ramosa* sp. nov. UT 23504 from sample 56 (578 feet to 579 feet).

PLATE II

Corals from Smelter's Quarry, Zeehan, ?Trentonian.

FIG. 16.—*Tetradium dendroides* sp. nov. Holotype MUGD 2260, Smelter's Limestone; external views x1.

FIG. 17.—*T. tasmaniense* Chapman. MUGD 2132; external view x1.

FIG. 18.—*T. conjugatum* sp. nov. MUGD 2130; external view x1.

FIG. 19.—*Lichenaria ?ramosa* sp. nov. MUGD 2256; external view x1.

FIG. 20.—?*Nyctopora* sp. MUGD 2131; external view x1.

FIG. 21.—?*Protaraea* sp. MU 199; external view x1.

FIG. 22.—*Propora* sp. cf. *hirsuta* Lindström; NM. Doubtfully from Smelter's Quarry, Zeehan, may be however from either Smelter's Quarry Queenstown or from Bubb's Hill near H.E.C. Tower 287, Victoria Pass, Lyell Highway; *a*, transverse; *b*, vertical.

FIG. 23.—*Tetradium tasmaniense* Chapman. Cotypes NM/13138-9, thin sections.

Corals from Smelter's Quarry, Queenstown. ?Trentonian or ?Richmondian.

FIG. 24.—*T. tasmaniense* Chapman. MUGD 2253; external view x1.

FIG. 25.—*T conjugatum* sp. nov. Holotype MUGD 2247; *a*. external view x1; *b*, transverse section x1·8.

FIG. 26.—*T.* sp. cf. *halysitoides*?. MUGD 2246; *a*, external view x1.

FIG. 27.—?*T.* sp. cf. *syringoporoides* Ulrich; MUGD 2250; *a*, external view x1; *b*. thin section x1·8.

FIG. 28.—*T. dendroides* sp. nov. MUGD 2255; external view x1.

FIG. 29.—*T. dendroides* ?var. MUGD 2243; transverse section x1·8.

Bubb's Hill, near H.E.C. Tower 287, Victoria Pass, Lyell Highway.

FIG. 30.—*Nyctopora* sp. NM; *a*, transverse; *b*, vertical.

FIG. 31.—*Plasmoporella* sp.; NM.

FIG. 32. *Plasmoporella* sp. NM specimen from one of three localities—Bubb's Hill, Queenstown Quarries or Zeehan Quarries, probably the first.

FIG. 33.—*Eofletcheria ida* sp. nov. NM.

King Mine, Zeehan.

FIG. 34.—*Aulopora* sp. Encrusting polyzoan. UT 23538, sample 145 (530 feet 6 inches). King Mine, Core No. 13, Zeehan, Tasmanian age unknown.

PLATE III

Ida (Wheelbarrow Bay), Port Cygnet District, S.E. Tasmania. Trentonian or Richmondian.

FIG. 35.—*Streptelasma* sp. cf. *aequisulcatum* (M'Coy); MUGD 2126.

FIG. 36.—*Tryplasma cerioides* sp. nov. Holotype MUGD 2123.

FIG. 37.—*Lichenaria ramosa* sp. nov. MUGD 2116.

FIG. 38.—*Tetradium ?compactum* sp. nov. MUGD 2121; *a*, transverse; *b*, vertical.

FIG. 39.—*Tetradium* sp. MUGD 2112.

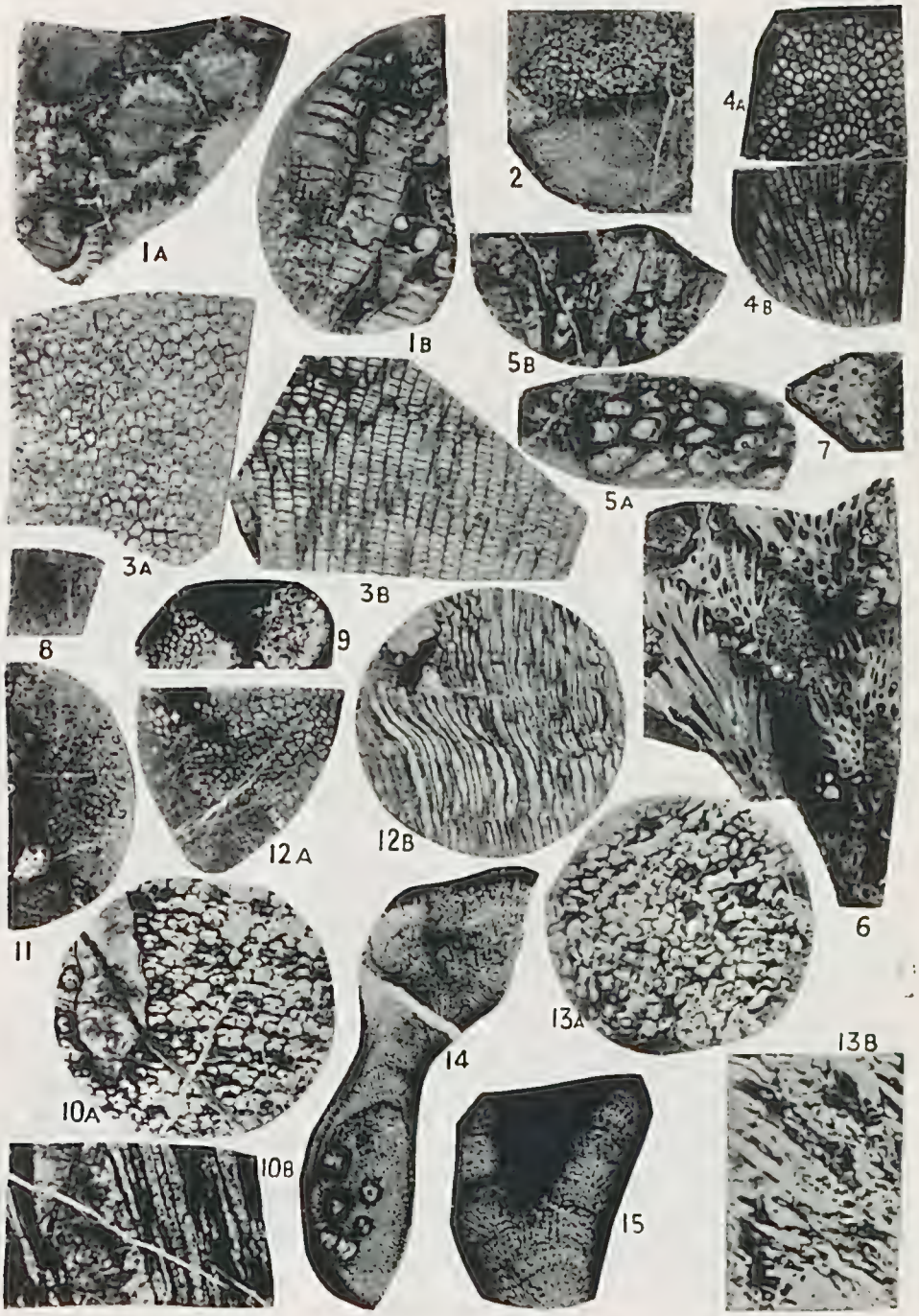
FIG. 40.—*Billingsaria banksi* sp. nov. Holotype MUGD 2113.

FIG. 41.—*Coccoseris ramosa* sp. nov. Holotype MUGD 2119.

FIG. 42. *Acidolites* sp. MUGD 2120.

FIG. 43.—*Acidolites* sp. MUGD 2114; *a*, transverse; *b*, vertical.

FIG. 44.—*Eofletcheria ida* sp. nov. *Holotype* MUGD 2128.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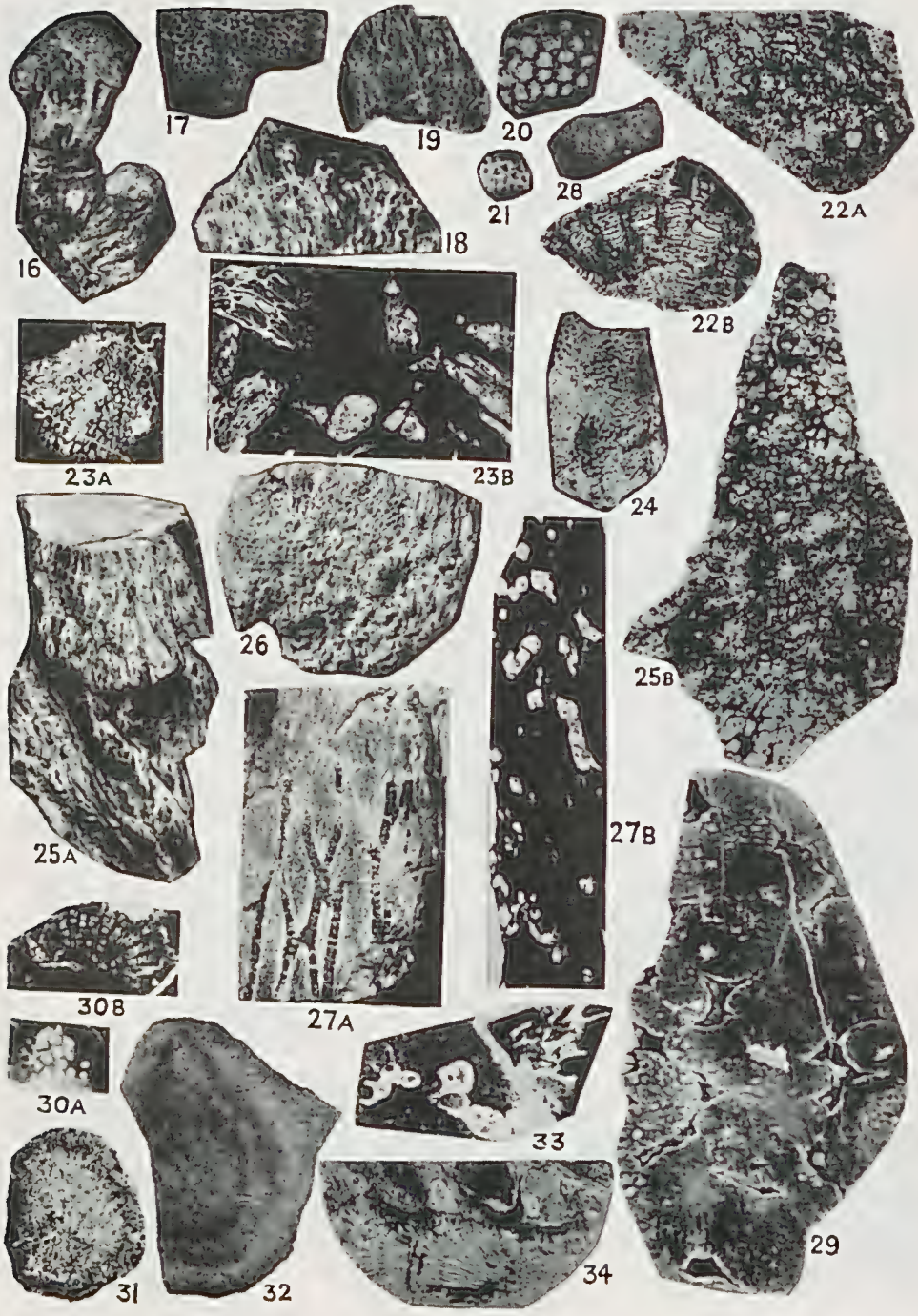
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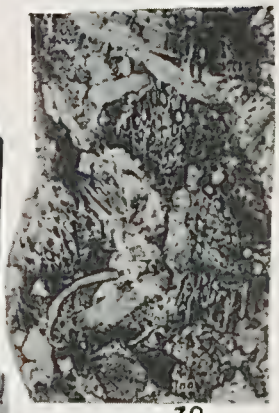
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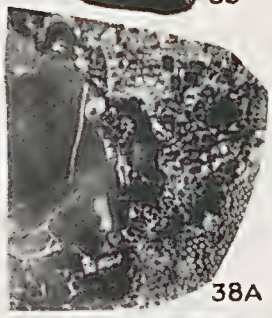
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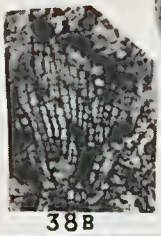
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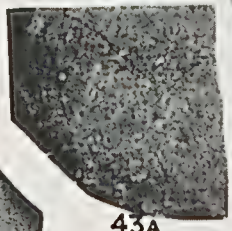
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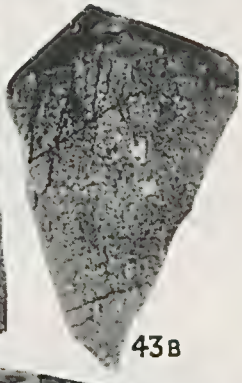
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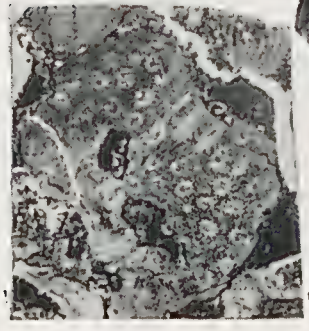
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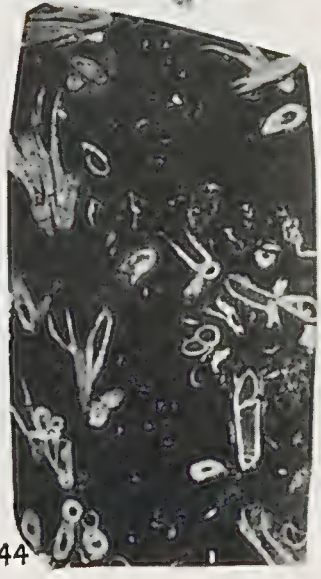
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The Orocline Concept in Geotectonics

Part I

By

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(with 22 text figures)

Abstract

The face of the globe shows many areas where orogenic belts wheel in trend through large angles, sometimes as much as 180°. Such a form could have one of two origins. Either the orogenic zone had that shape from the beginning, or the bend represents an impressed strain (here defined as an *orocline*). Classical geology has always made the first assumption, explicitly or implicitly, using the concept of cratons around which the orogens were moulded. However, logical scientific analysis demands that we should also examine the consequences of making the second assumption. Twenty-five such cases occur on the face of the globe. In every case the major structures of the region not only agree with the assumption, but lesser compressional and tensional structures fall where they would be predicted by the impressed strain theory, and quite unexpected solutions of other major tectonic problems result. Six of these oroclines are worked out in detail in this paper. Six more are presented more briefly. When all such oroclines, together with other identifiable strains, are reversed, there appears a Laurasia substantially identical with that deduced by Du Toit on wholly different grounds.

Introduction

Sir James Hall first made the induction that observed contortions in strata were actual deformations of beds originally flat, and therewith structural geology began. A century and a half has seen much progress, but most of it has been towards increasing our understanding of the internal anatomy of orogens. Little has been done about the deformation of the orogenic belt as a whole. Again, with the outstanding exception of Suess and his disciple Argand, the bias of structural nomenclature is towards the deformation of the profile cross-section of the orogen, not its shape in plan. There are adequate terms for the deformation and dislocation of strata in the vertical plane, and even for the further deformation in the vertical plane of such folded structures but there is no term for deformation of structures in plan, and still less for the impressed bending of the orogenic belt itself, or for its longitudinal stretching. Yet in view of the horizontal compression involved in orogenesis, and its longitudinal variation, there must be substantial deformation in plan. This is emphasised by a consideration of the relative dimensions of an orogen and the physical limits of its possible deformation.

The order of the dimensions of a mountain system is 10^3 km. or more long by 10^2 km. wide by 10^1 km. deep. Reduced to a model we might think of it as a strip-lamina. Its plan and cross section are shown to

scale in A of Fig. 1. When such an orogen is folded, deformation in the vertical direction is closely confined by gravity and isostasy. Before and after orogenesis the locus of the centre of gravity of elements of the strip departs little from a gravitational isopotential surface, and the cross-section of the deformation of the orogen is still contained wholly within the lens B. It is quite impossible for the orogen to be deformed into the form C. The dimensions of length and breadth, on the other hand, are not confined or limited. Alpine geologists speak in terms of 500 km., even 1200 km., of horizontal translation. Only 400 km. away on the strike of this compression is the central plateau of France where the Alpine compression is nil or negligible, and 400 km. away normal to the strike of the Alps the Apennines disclose strong compression in a quite different direction, of an amount which has not been closely estimated but would surely be of the order of 10^2 km. These facts are among the most certain data of field geology.

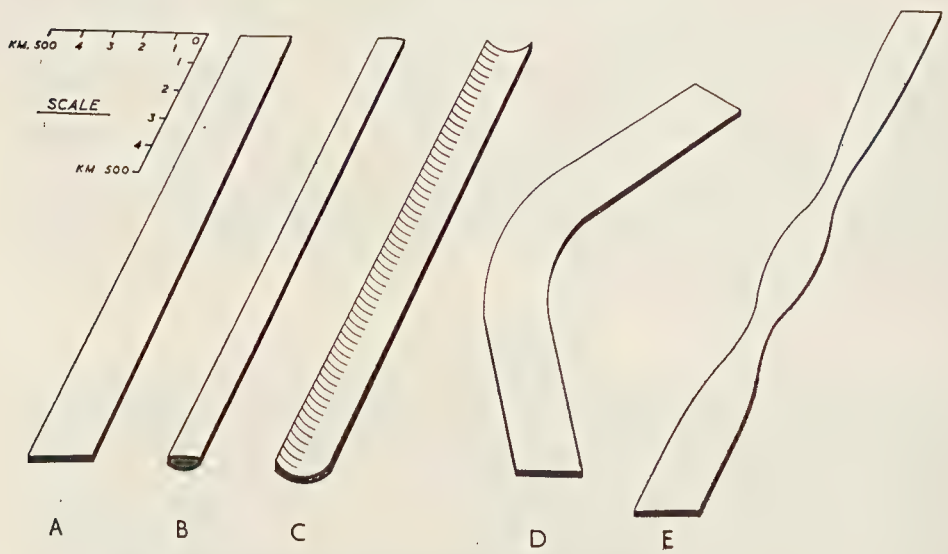

FIG. 1.—The relative dimensions of an orogen.

When such phenomena are closely analysed, it will be found that their geometry and plan relations can only mean strong movements in different directions *with differential rotation through large angles* in the plan view. It is impossible to escape the implication of great change of surface shape, bending, shrinking and stretching in the non-limited dimensions of length and breadth (that is in plan). This deformation might reasonably be far greater than the change of shape in the end section, and there seems no logical reason why deformation by bending in plan to the form D of Fig. 1 might not occur or stretching to the Form E.

It is reasonable to examine the surface pattern of the globe to see whether there are structures which could be of such kind. If this quest is successful, we should follow out the consequences of assuming that

they are in fact deformations in plan, of straightening and restoring them to their implied former positions. This procedure has yielded surprising results.

Evidence is presented that such structures probably do exist and that, if they are herein correctly interpreted, they are in fact the most important structures of geotectonics, they provide the key to the understanding of the evolution of the continents, and integrate all the other structurel features of the earth into a coherent pattern. The concept opens a new vista of tectonic understanding quite as important and as fundamental as Hall's initial induction.

Definitions

For an orogenic system which has been flexed in plan to a horse-shoe or elbow shape, the name *orocline is proposed.* (Greek ορος, mountain, κλινο to bend.) Orocline replaces the term geoflex which has already been used for such structures in a preliminary note (Carey, 1954A) and in lectures given before the Geological Society of Australia, Geological Society of South Africa, and the Pan Indian Ocean Science Congress. However, orocline is more precise, in that it is specifically the orogen which is bent not the associated shields; in addition, geoflex is a hybrid.

For a mountain system which has been torn free from the continental shield to which it is genetically related, the name *diothesis* is proposed. (Greek, διωθεω, to tear away, pluck out. Diothesis, o long as in both, and accented.)

For a diothesis which has been stretched by significant fraction of its length, the name *orotath* is proposed. (Greek, ορος, mountain; ταθεις, to stretch.)

Examples interpreted as belonging to each of these categories will be given in turn, with evidence supporting such interpretation. It is intended that these terms should be reserved for the really major structures of the earth's surface—of the order of 1000 km. long. It is not proposed that they should be applied to structures less than 100 kilometres long. The term megashear has already been used for transcurrent faults of very large displacement. This term will be used herein where the displacement exceeds 100 km. Such a fault might be conceived, not as part of an orogen, but as a co-ranking structure which offsets the orogen as a whole.

The Rotation of Spain

The Pyrenean Compression

The Pyrenees form a belt of intense compression folding and overthrusting, which is widest and strongest at the eastern end against the Gulf of Lyons and diminishes in width and intensity westwards to the head of the Bay of Biscay, where the main movements die out. Subordinate folds continue the trend along the north coast of Spain as far as Oviedo. The pattern of the late Mesozoic and Tertiary folding is shown in Fig. 2 in which the intensely compressed zones are hatched and cross-hatched; in the more moderately folded areas the principal anticlinal trends are shown in full lines and synclinal trends in broken lines.

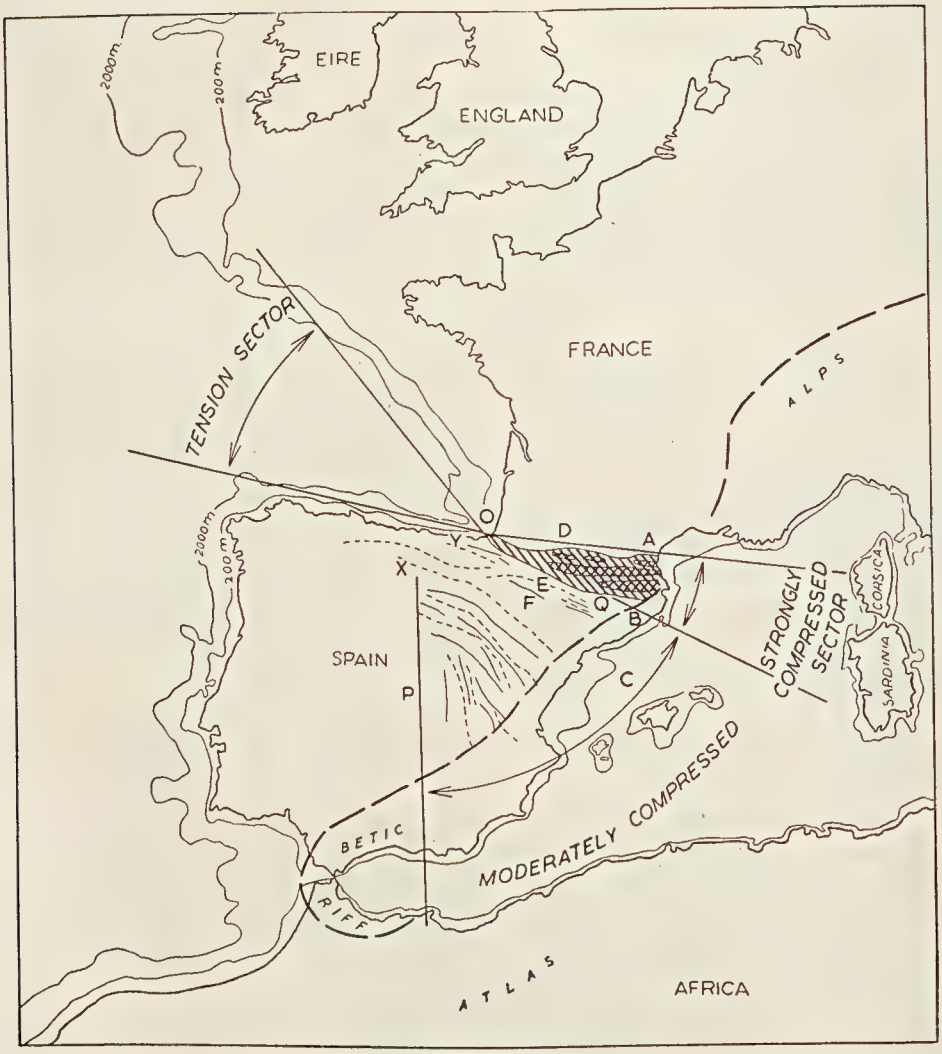

FIG. 2.—The Pyrenean compression.

Now a section drawn across the Pyrenean compressed belt along the line AB in Fig. 2 would show intense compression and shortening. If we consider only relative movement we may regard one side *A* as fixed. Then the shortened section indicates that before the folding the point *B* must have been at some point such as *C* on *AB* produced. A parallel section at *DE* would also show folding and shortening, but less in amount than at *AB*. Considering the relative movement of *D* and *E*, *E* must originally have occupied some point such as *F* on *DE* produced, *EF* being less than *BC* since the shortening is less. Finally, a third parallel section through *O* or a little west of it will show no folding, hence, no shortening, that is, the point *O* will not have been moved by the folding.

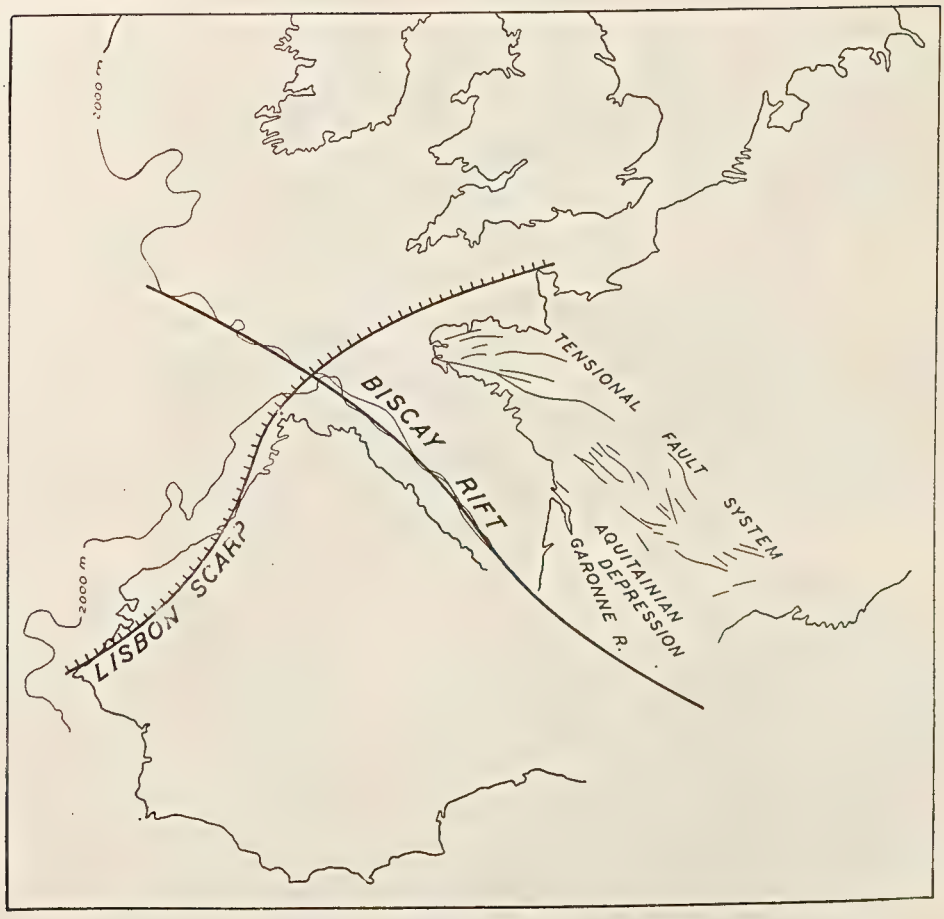

FIG. 3.—Tensional structures in the Pyrenean region.

The pattern of the Pyrenean compression therefore implies that the line *OEB* was rotated about *O* relative to the line *ODA*, from some position such as *OFC*. The precise position could theoretically be re-established by a careful determination of the amount of shortening represented in the Pyrenees.

Such a compression of a sector by shortening through the angle *BOC* can only mean that within the circular area described by rotating *OB* about *O* there must be a complementary tensional area which has been stretched through a sector equal to *BOC*. If we go back round the arc looking for such a tensional area we come to the Bay of Biscay. The Bay of Biscay (as determined by the 200 metre isobath whence there is a steep slope to the floor) has a triangular shape opposed apex to apex to the Pyrenean compression. The floor of this area lies between

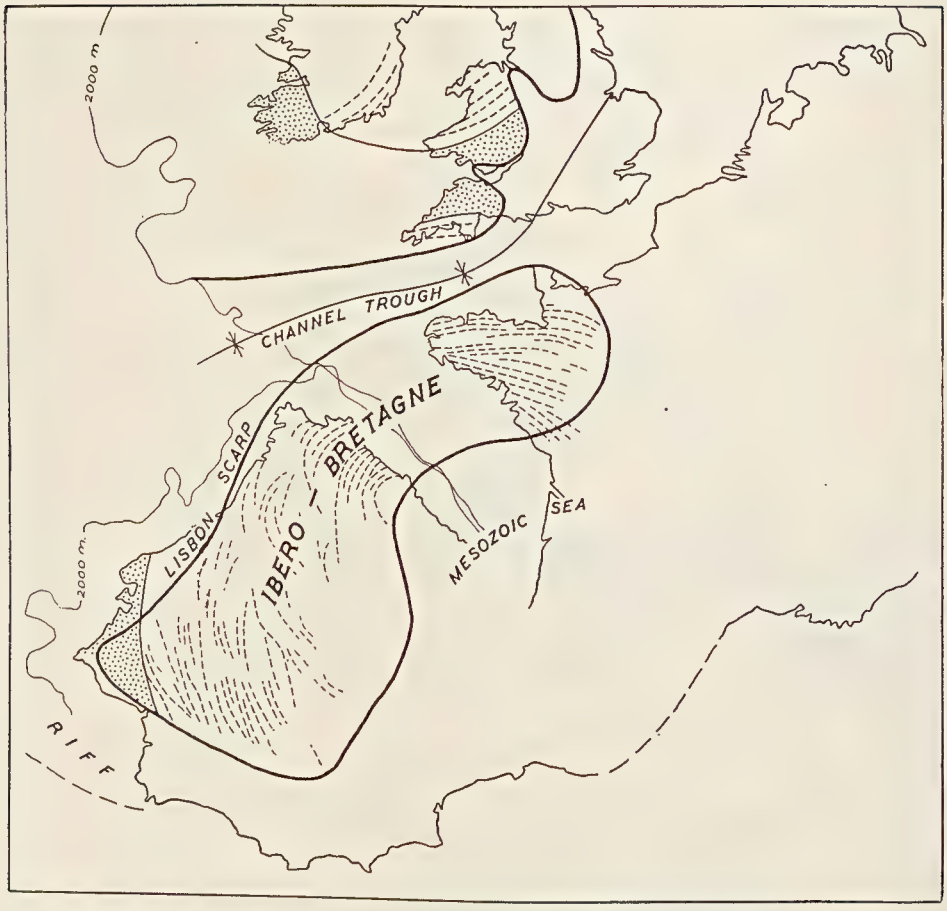

FIG. 4.—Matching of structures across the Biscay Rift.

3 and 5 km. below the platforms of France and Spain. This approximates the normal difference in level between continents and ocean floors of the Atlantic and Indian type. The Bay of Biscay should therefore be regarded as normal ocean floor. It could not be foundered continent, for to depress continental material to such a level would involve very large negative gravity anomalies across this area.* Further confirmation is given by submarine "seismic" spreads carried out by Bullard and Gaskell (1941) and Hill and Laughton (1954) which show that the steep continental slope running from south-west of Ireland to the head of the Bay of Biscay marks the boundary between typical continental and oceanic profiles with the Mohorovicic discontinuity rising from depths of 30 to 40 km. to very shallow depths.

* The only escape from this conclusion is the suggestion by Lees (1954, p. 402) that the Mohorovicic discontinuity is a paramorphic phase change, which, however, is incompatible with the very different depths of the discontinuity under continents and oceans respectively.

If the Pyrenean compression is smoothed out by rotation of *OB* about *O* away from *OA* the movement would (qualitatively) close the Bay of Biscay by bringing the Spanish continental shelf into contact with the shelf off Brittany. The simplest interpretation of the morphology of this region is therefore to regard the Bay of Biscay as the tensional rift demanded by the geometry of the Pyrenean compression, since there is no other feature in the region which has the required characteristics, and the magnitude of the tension called for is certainly great enough to have permanent physiographic expression. It seems therefore reasonable to conclude that the Spanish Peninsula was rotated through some 35° during the Pyrenean folding.

This should be capable of being checked geologically by studying second order strains. It would be surprising if a rotary compression of the magnitude indicated by the Pyrenees should occur without other evidence of rotary compression with the same general origin: likewise we might expect a rift on the scale of the Bay of Biscay to be accompanied by subsidiary tensional fractures parallel to the primary rift and with the same sense of movement. Such confirmatory strains are in fact present, and indeed, apart from the Pyrenees and the Biscay gulf, they are the dominating morphological features of the region.

Subsidiary Rotary Compression

It has already been mentioned that there are a number of folds in north-eastern Spain which appear to be related to the Pyrenean compression. These folds, the trends of which are shown on Fig. 2, have quite large dimensions, but represent much less intensity of compression than the Pyrenees. Their pattern also implies a rotation of the Iberian Peninsula in the same sense as the main Pyrenean compression and the Biscay rift. For, if we assume as a first approximation that each of the folds shown represents the same amount of shortening, then there is five times as much shortening between *P* and *Q* as there is between *X* and *Y*. This means that the line *PX* has been rotated towards the line *QY* during the folding. This also demands a complementary tensional sector. Hence, we may conclude that the tensional rift represented by the Bay of Biscay is the complement not only of the intense Pyrenean compression but also of this Ebro bundle of folds, the compression of the former being apparently appreciably greater than that of the latter.

The centre of the rotation implied by the Ebro folds seems offset somewhat to the west of the Pyrenean and Biscay centre. This should not be surprising, for it would require a very special distribution of forces to produce pure rotation of a non-pivoted tabular body. Rotation accompanied by some translation in the same sense is a much more probable type of movement. This seems to have occurred in the case of Spain.

The angle of the compressed sectors on Fig. 2 is not a measure of the angle through which rotation has taken place. These angles merely limit the distribution of compression effects, which theoretically could be distributed through the whole of the sector complementary to the tension sector, or be confined to one or more weak zones. The angle of compression could only be determined by measuring the whole shortening

along an arc both for the Pyrenees and the smaller folds of the Ebro group and dividing the measured shortenings by the radical distances from the centre of the sector. These angles should add up approximately to the rift angle of the Bay of Biscay. Theoretically this offers a method of testing the hypothesis, but it would be tedious to carry out, and the limits for subjective interpretations in determining the amount of shortening in the Pyrenees are probably great enough to make the check only qualitative. Nevertheless, it would be useful to make the attempt.

Second Order Tension

A conspicuous feature of the geological map of France is the group of tension faults which trend south-easterly from Brittany almost to the mouth of the Rhone. This group of faults, shown on Fig. 3, was active during the Upper Mesozoic and Tertiary and was responsible for the development of the Aquitainian basin. It may also govern the present coastline from the mouth of the Garonne to the tip of Brittany. The outcropping faults of the system are distributed through a belt 100 kilometres wide and 700 kilometres long. Towards the south-west they become submerged under the younger sediments of the Garonne valley. It is not impossible that they may be present all the way to the Biscay Rift. This fault system is clearly a major tectonic feature of the region,

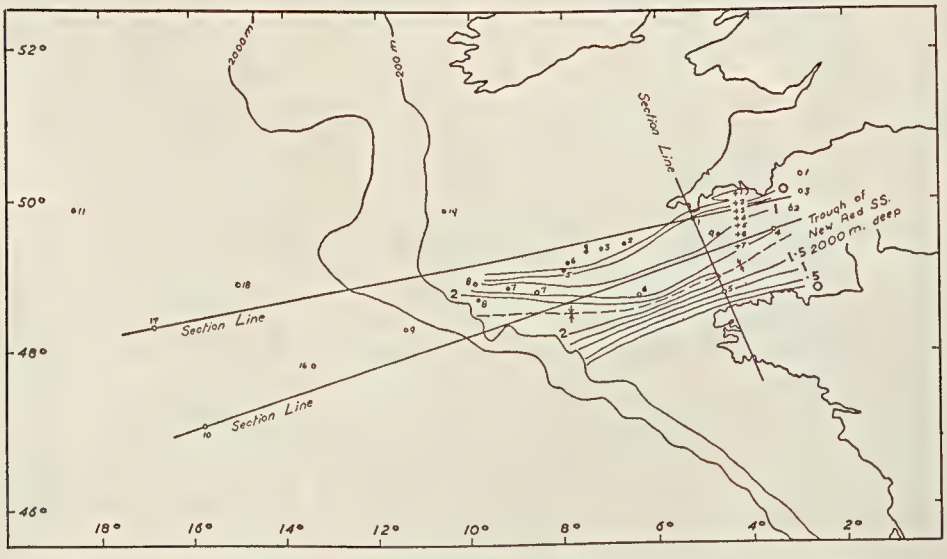

FIG. 5.—Trough of Mesozoic sediments revealed by submarine seismic investigations in the English Channel and Bay of Biscay. Open circles numbered 1 to 19 show the positions of seismic measurements by Hill and Laughton (1954), filled circles 1 to 8 those by Bullard and Gaskell (1941), and crosses 1 to 7 those by Hill and King (1953). Contours (in kms. below sea level) show the floor of the Channel Trough of Mesozoic sediments.

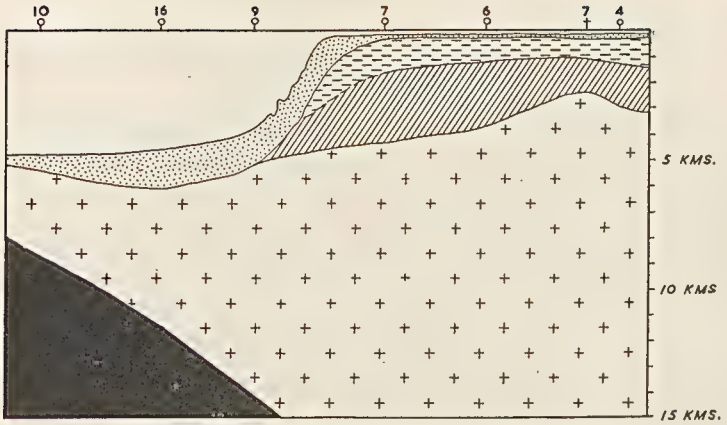

Figure 6 SECTION ALONG CHANNEL TROUGH

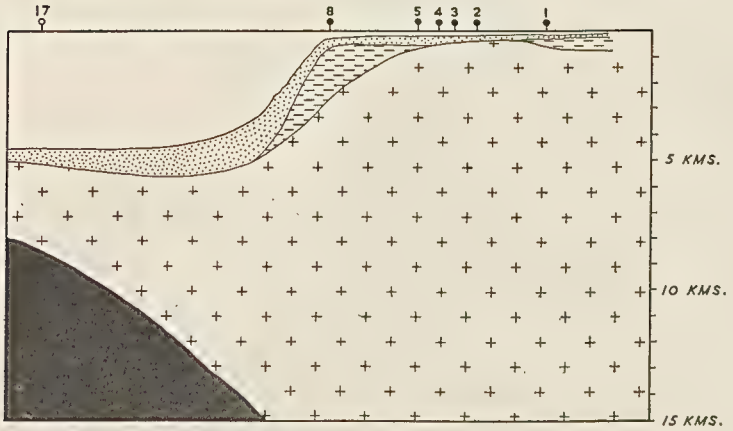

Figure 7 SECTION ALONG CORNWALL RIDGE

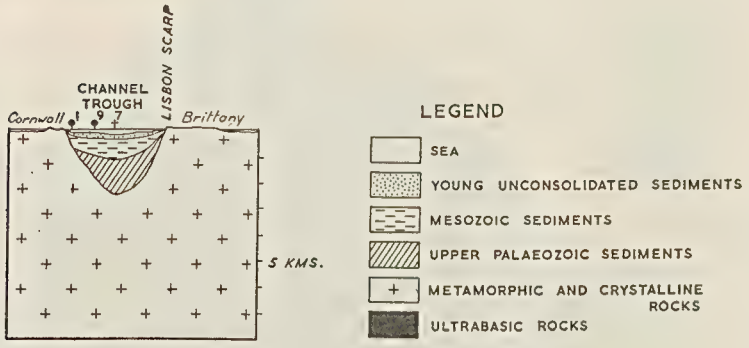

Figure 8
SECTION ACROSS CHANNEL TROUGH

FIGS. 6, 7 and 8.—Section through the Mesozoic trough of the English Channel along lines shown in Fig. 5. These sections are compiled from seismic results and published sections of Hill and Laughton and Bullard and Gaskell, together with known land outcrops and sub-channel core sampling of New Red Sandstone.

and since it parallels the postulated Biscay Rift the reality of tensional conditions with this trend at the required time is unequivocally established.

Matching of Structures Across the Biscay Rift

As a further geological check of the alleged rotation a comparison should be made of the structure and facies of the rocks on opposite sides of the Bay of Biscay, which would have been in close proximity prior to the movement. Attention may be drawn to the salient features which show up on the International Geological Map of Europe (1 : 1½ million). A tightly compressed bundle of Hercynian folds strikes north-westwards through Brittany, curving towards the west (Fig. 4). A similar tight knot of folds strikes south-south-east in north-western Spain, curving to south-eastwards through Spain and Portugal. Under the present configuration of the lands, these fold bundles are both chopped off and strike into featureless ocean which, as we have seen, cannot reasonably be regarded as consisting of such continental material. Under the reconstruction shown on Fig. 4 these fold bundles are the continuation of each other. The reversal of the rotation of Spain sets them end to end. The curvature of each bundle is in the same sense, and together they form a smooth continuous arc. Each segment has a core consisting of crystalline metamorphic rocks intensely injected by granites which also intrude an overlying sequence of strongly folded Cambrian, Silurian and Devonian strata.

This Ibero-Bretagne massif is cut off on the west by the Lisbon scarp, where crystalline and Palaeozoic rocks of the Meseta drop down to the coastal plain of Portugal. This scarp, or flexure, which seems very similar morphologically to the Darling Scarp of Western Australia, runs obliquely out to sea and strikes towards the rift gap of the Bay of Biscay. A similar sharp drop from the metamorphics of Brittany to a trough of Mesozoic sediments under the English Channel, has recently been proved by the submarine seismic investigations (see Figures 6, 7 and 8). The closing of the Biscay rift gap as shown on Fig. 4 places the Lisbon scarp end to end with the structural downthrow from Brittany to the Channel Trough, and thus gives further confirmation to the proposed reconstruction.*

Fig. 4 also shows the pattern of the Liassic transgression, which is representative of the broad basins of shallow epicontinental sedimentation that occurred behind the Alpine-Betic fold belt during the Mesozoic Era. The Liassic is chosen in order to confine the palaeogeographic map to a reasonably short time range. A comparable picture is given by other Mesozoic epochs. The Liassic boundary as reconstructed after closing the Bay of Biscay shows an eastward bulge in Brittany and westward bulge towards Oviedo, which fall in just the places expected from the relations of the sediments themselves. For in Brittany, where the Liassic sea transgressed the Palaeozoic folds, each series of the Mesozoic is overlapped in turn by the succeeding series, indicating a palaeogeographic promontory eastwards there, whereas in Oviedo the complete

* Professor King's paper (King, 1954) which has reached me while this manuscript was in press, adds much more detailed information regarding the post-Palaeozoic history of the English Channel. However the essential features here cited remain unaltered. Compare for example fig. 5 herewith with King's figs. 5 and 6.

Mesozoic sections indicate a complementary westward gulf. This pattern then also agrees with the proposed reconstruction.

To sum up, the following structural units all match up in order across the restored Biscay rift: the Liassic sea of southern France and eastern Spain, the Ibero-Bretagne fold bundles of Palaeozoic and crystalline rocks, the Lisbon Scarp and the submarine flexure off Brittany, and the Mesozoic sediments of the Channel trough and of the coastal plain of Portugal. Unless we close the Bay of Biscay we are faced with the problem of the continuation of these structures, for all eight broken ends run out to the Bay of Biscay which is demonstrably underlain by very different rock.

The Baluchistan Orocline

The Cretaceo-Tertiary fold-system of Persia has a south-east trend for 2000 km. from Asia Minor to the Hormuz Straits. Within the next

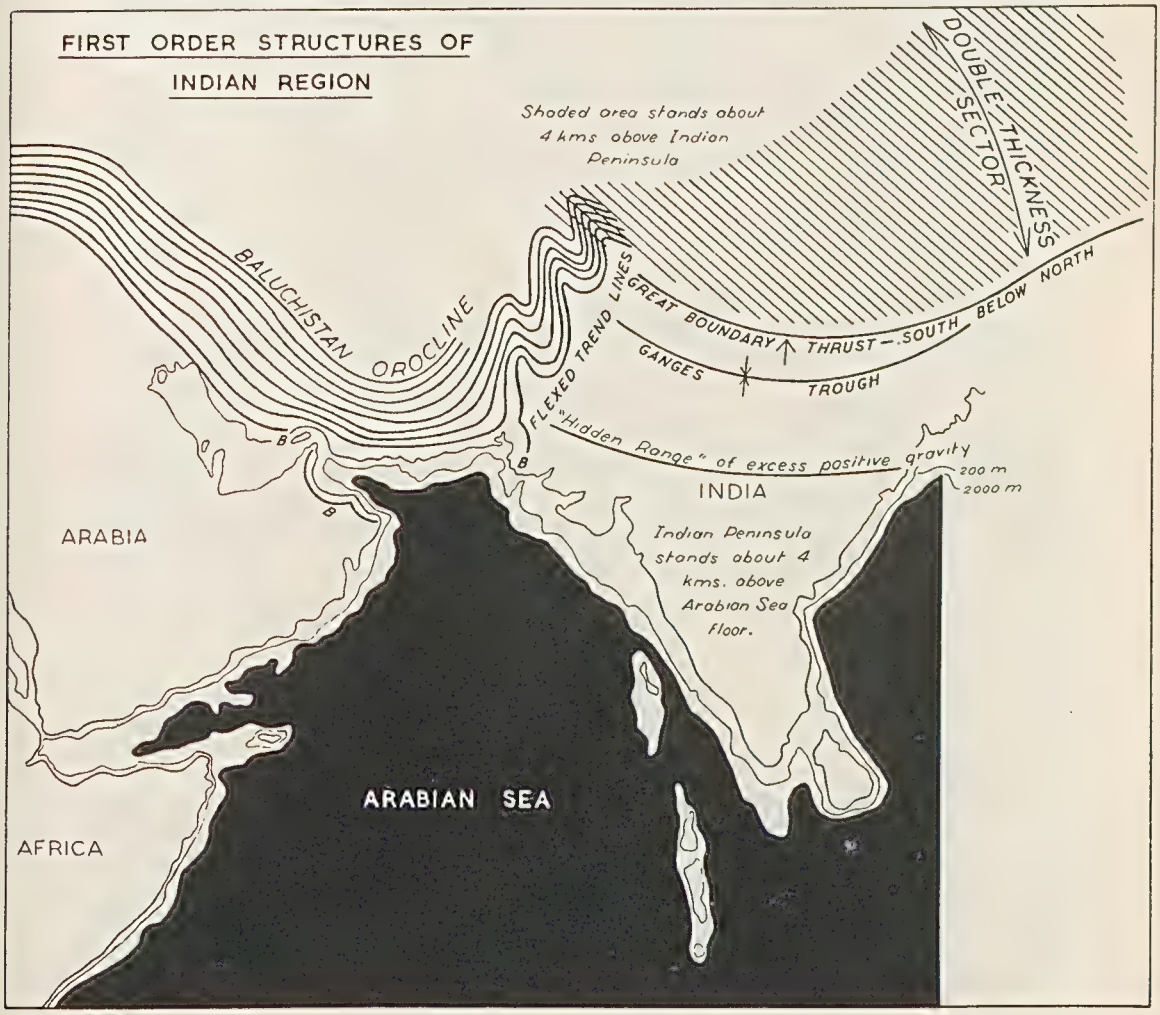

Figure 9.

1000 km. the strike wheels through 120° to an almost northerly trend into Kashmir (Fig. 9). Here there is another wheel round the Punjab into the Himalaya. Let us consider first the bend in Baluchistan. There are two possible interpretations of such a structure. Either the mountain system developed in this shape from the beginning, or the 120° wheel is a superimposed strain due to the bending of an orogen in plan. Classical geology has consistently made the first assumption, using the theoretical concept of strong passive shields around which and between which the orogens were moulded. However, logical scientific analysis demands that we should also examine the consequence of making the second assumption; particularly we should examine the relations of such an orocline to the other first order structures of the region.

Consider first the Arabian sea, a triangular gap between the continental blocks of India and Arabia. Does not the shape of this area—apically opposed to the Baluchistan orocline—recall the relation of the Bay of Biscay to the Pyrenees? Straighten the suggested Baluchistan orocline and the Arabian Sea is closed (Figs. 9, 10 and 12). This pattern of orocline and apically opposed triangular rift will be found to repeat itself with impressive regularity on the face of the globe. The coasts of this gap are fault coasts, generally oblique to the trends of structures and stratigraphy. Yet the floor of this sea is certainly not foundered continent. The gravity observations indicate that although there is a regional negative anomaly in the northern Indian Ocean-Arabian Sea region, the departure from isostasy is small, which would not be the case if the floor consisted of a continental shield depressed 4 km. For the foundering of a block similar to the Deccan Peninsula through 4 km. would require the displacement laterally of 4 km. of material from beneath, which would result in a mass deficiency of three thousand million tons per square km. Irrespective of isostasy this would result in a gravity anomaly of several hundred milligals, which would show up in the free air anomalies even before any Bouguer or isostatic adjustment. Moreover, where seismic work has been done on such seas hitherto regarded as foundered continent, it has been found that the Mohorovicic discontinuity is not far below the sea bed, indicating, not foundered continent, but a gap between continent material (Hess and Maxwell, 1933 for the Carribbean, and Officer 1954 for the south-west Pacific).

Next consider the Tibetan Plateau, a region of post-Palaeozoic compression shown hatched on Fig. 9. Like the Pyrenees this tapers, from a width of some 1000 km. on the 100th meridan to less than 300 km. on the 70th meridan. Does this tapering of the width mean, as in the case of the Pyrenees, that there has been rotation about *Y* (Fig. 10)? Or are we to assume that the compression was much less concentrated in the east than the west?

The southern front of this Tibetan plateau is known to be intensely overthrust, the south side underlying the north side. The Siwaliks of the foothill region show at least as much compression as the Swiss Molasse, and although the high Himalaya has not received the intense study which has revealed the compression of the Alps, preliminary studies suggest that at least the same order of shortening has occurred—certainly of the order of hundreds of kilometres. Straighten the Baluchistan orocline and the Himalayan thrusting is also put back.

The Tibetan plateau stands about four km. above the level of the Indian peninsula and other continental regions generally. The latter, in turn, stand about four km. above the general level of the Arabian Sea and the ocean floors. It has often been pointed out that this implies that the Tibetan plateau is underlain by twice the normal thickness of continental material. For, if one floating tabular iceberg has twice the freeboard of another floating tubular iceberg, the first is twice as thick as the second, irrespective of the densities of ice and water. Likewise, a continental mass such as the Tibetan plateau, must be twice as thick as another continental mass such as the Indian peninsula which has only half the freeboard above the ocean floor. Restore the Baluchistan orocline, and the problem of the double continent is automatically solved, for the Indian mass is removed from beneath the Tibetan mass. The width of the double thickness area is a direct measure of the compression. If the volumes of material involved are considered, this will be seen to be true irrespective of whether one continent is pushed below the other, or the two continents are crumpled face to face until the thickness is doubled (Fig. 11). The tapering of the high plateau shown on Fig. 10 does then imply rotation, for the amount of compression involved in the Himalaya would be of the order of 1000 km. at the eastern and only two hundred km. in the west.

Associated Tension

When the Baluchistan orocline is reversed the Indian peninsula is restored to a position such as that of Fig. 12. In the restored position the postulated Arabian Sea rift becomes an integral part of the greatest rift system of the globe. The tensional genesis of the African rift valley system has been hotly debated for several decades but there is no doubt concerning the normal fault margins of the Arabian block. Further, it was pointed out by the writer at the Pan Indian Ocean Science Congress at Bangalore in 1951 that the fault troughs which let down the Gondwana rocks into the shield of peninsular India have a radial pattern consistent with tensional strains associated with the postulated Baluchistan orocline (Fig. 12). Ahmad (1952), following Gee, has argued that these fault troughs are largely Upper Mesozoic in age.

Associated Transcurrent Displacement

It was pointed out in the discussion of the rotation of Spain that pure rotation of tectonic blocks is physically improbable, and that rotation would usually be accompanied by transcurrent displacement in the same sense as the rotation. This is in fact indicated by the offsetting of apparent centres of rotation X and Y (Fig. 10). Transcurrent displacement of India in the direction XY is also implied by the tensional opening of the Red Sea and the Persian Gulf, and by the double knee action of the Baluchistan and Punjab oroclines, which developed *pari passu*, and are straightened simultaneously when the Baluchistan orocline is restored (Fig. 12).

Palaeogeography

The broad geology of the coasts thus brought together is similar. Extreme caution is necessary, however, in drawing positive conclusions concerning the former juxtaposition of continents by such evidence alone. The writer has found it possible to present separate cases for matching pairs of coasts, with general geological similarities and even striking parallels, but wherein the correlations were mutually exclusive. If one such case is certainly wrong, other similar cases become suspect. This is particularly true in correlation of areal distributions as distinct from linear features such as orogens and facies changes.

In the Indo-Arabian case the Deccan peninsula, the Arabian block, and Somaliland are all old stable Pre-Cambrian shields with overlying basins of Jurassic and Cretaceous rocks. Towards the north these shields slope gently under increasing thicknesses of Tertiary and Mesozoic strata which overlie marine Palaeozoic sediments of shallow shelf facies. There are no structures striking transverse to the coasts which are not reasonably

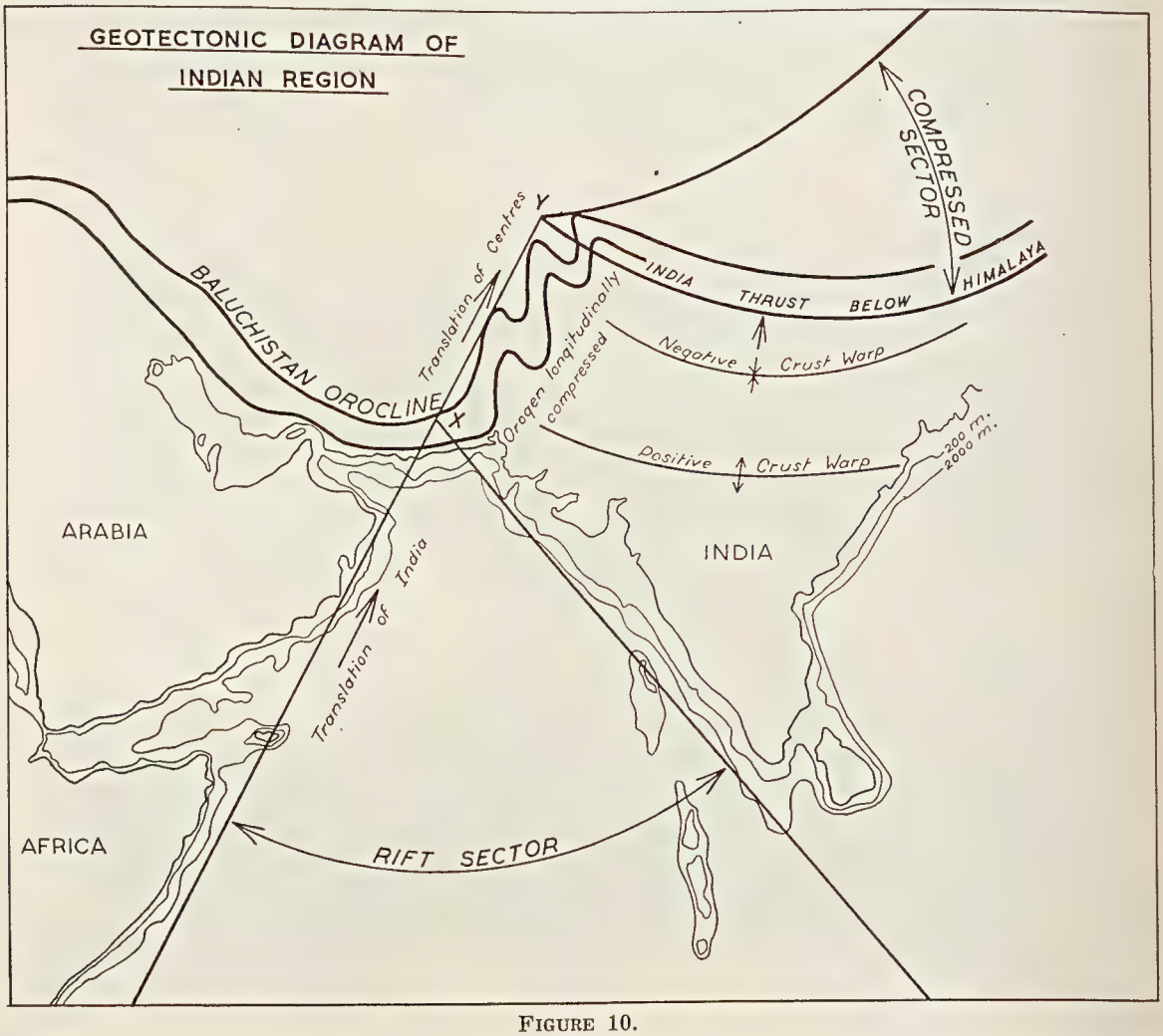

FIGURE 10.

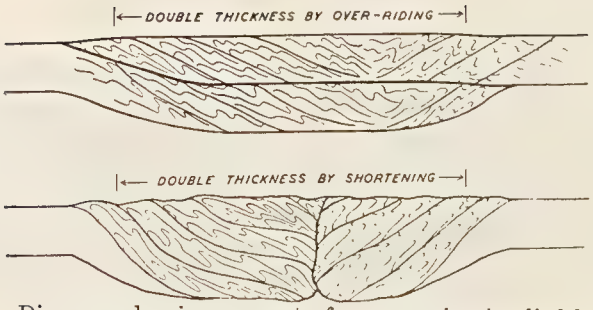

FIG. 11.—Diagram showing amount of compression implied by double continental thickness.

matched on the coast set in apposition to it. It is reasonable to conclude that whereas the geology of the opposed coasts may not, on available evidence, *prove* their former juxtaposition in the manner proposed from the study of the first order strains, the geology as known is quite consistent with this interpretation, and forms a coherent palaeogeographical picture. This has been studied in some detail by Ahmad (1952).

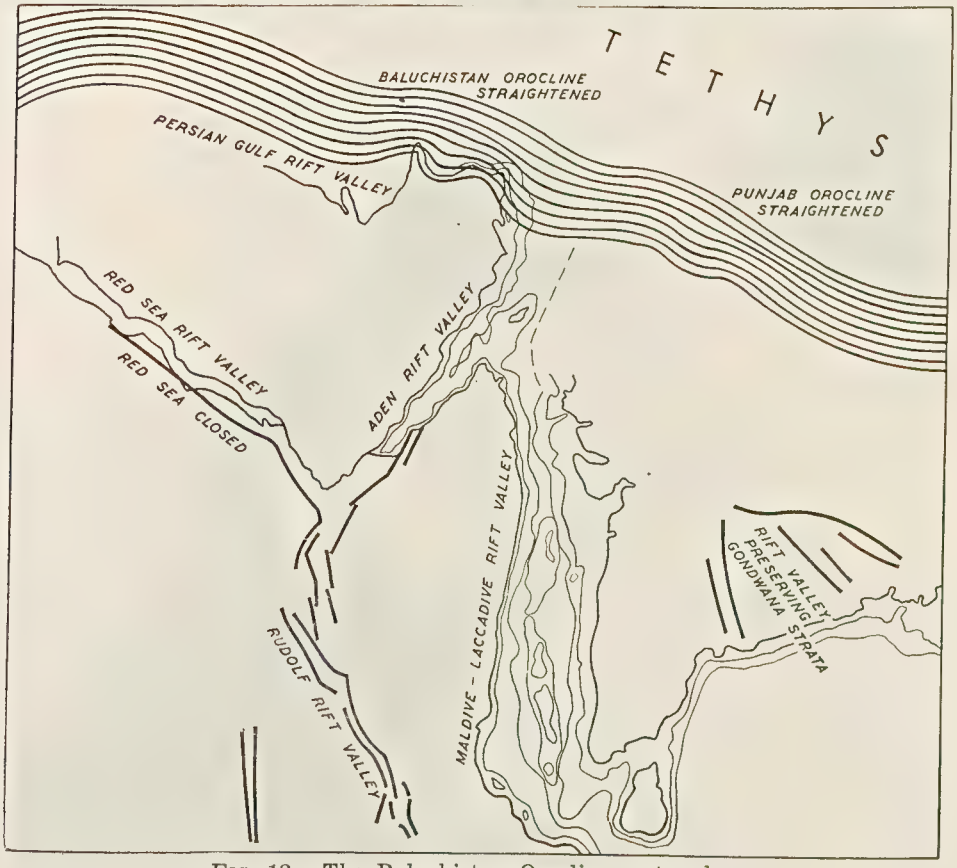

FIG. 12.—The Baluchistan Orocline restored.
[NOTE: For "Rift Valley" on India, read "Rift Valleys".]

The Case for the Baluchistan Orocline

To sum up, the induction that the wheel of the mountain systems through 120° in Baluchistan is an orocline simultaneously explains all the other first order structures of the region and is consistent with the smaller structures. Reverse the Baluchistan orocline and the Himalayan overthrusting is also reversed, the Indian Peninsula comes out from beneath the Tibetan Plateau, the triangular rift of the Arabian Sea is closed, and the problem of the missing fault block solved. Whether the new orocline induction be right or wrong, it must be conceded that it integrates in one act all the great geomorphological features of this region.

The Alaskan Orocline

When the Rocky Mountains are followed northwards through Canada into Alaska, the fold trends wheel through about 75° (Fig. 13). A good deal of this bending however is very local and is recovered in complementary inflections, but viewed regionally there is a deflection in the trends of about 30°. As in the other cases already discussed, there is a triangular tension rift sector (the Arctic Ocean basin) apically opposed to the centre of the wheel in strike. This wheel in trends then has the

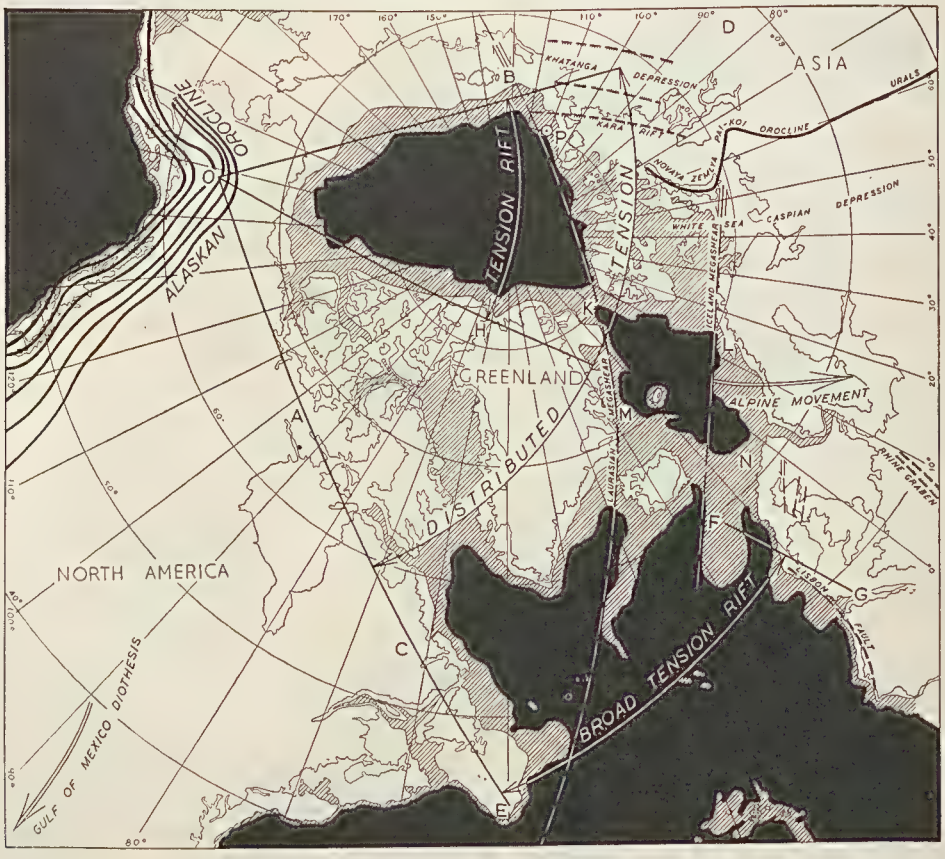

Fig. 13.—The Alaskan Orocline.

FRACTURE PATTERN OF NORTH ATLANTIC
(BEFORE PARTING)

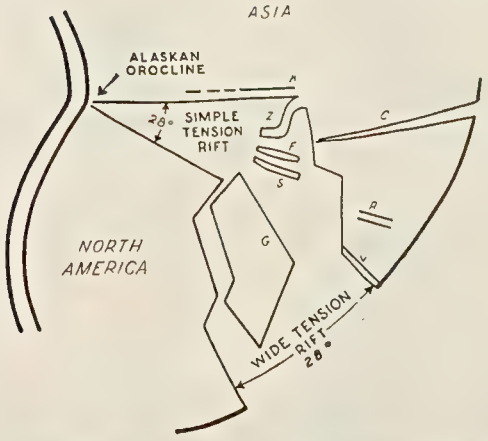

FIG. 14.—Diagram illustrating fracture pattern of Alaskan Orocline.

C. Caspian—White Sea depression.
F. Frans Joseph Land.
G. Greenland.
K. Khatanga Rift.
L. Lisbon Fault valley.
R. Rhine Rift valley.
S. Spitzbergen.
Z. Novaya Zemlya Oroclines.

morphology of an orocline and to be consistent we should follow out our induction and examine the consequences of assuming this bend to be an impressed strain. According to the agreed assumption of this investigation the orocline should be straightened and the rift sector closed. This act closes not only the Arctic basin but also the North Atlantic Ocean, for the gap between Newfoundland and Ireland also subtends 28° *at the centre of the orocline* (*ECO, GFO,* Fig. 13). The pattern is made clear by comparing the map in Fig. 13 and the diagram, Fig. 14. Three zones complementary to the Alaskan orocline may be distinguished in the tensional rift. The inner zone, *HOB,* is a simple tension rift sector of about 28° opening, quite similar to the Bay of Biscay and the Arabian Sea. The outer zone is the sector annulus *CEFG* where there is again simple rift tension, which again subtends an angle of about 28° at the

origin. These inner and outer simple rifts are connected *en echelon* through a wider embracing zone of distributed tension (the sector annulus *ABCD*) where the tension is distributed through 80° but may be presumed to add up to about 28°.

This distributed tension zone is expressed by the Greenland, Barents and Kara Seas, and the Khatanga, Davis Strait and Baffin Bay troughs. Many authors have argued that there is a large transcurrent fault along Robeson channel along which Greenland is displaced relative to Canada, thereby causing a tensional depression now expressed by Davis Strait and Baffin Bay (e.g., Wegener 1924, p. 58; Taylor 1928, Fig. 1; Bucher 1933, Fig. 99; Du Toit 1937, p. 135).

The East Greenland Basin is trapezoidal in shape. The sides, *KL* and *MN*, of the trapezoid are radial from the centre of the Alaskan

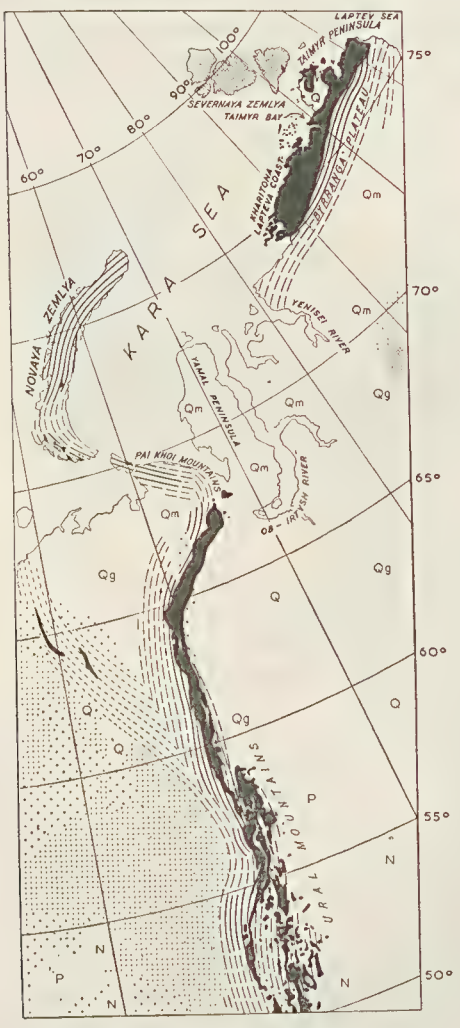

FIG. 15.—Novaya Zemlya and Pai Khoi Oroclines.

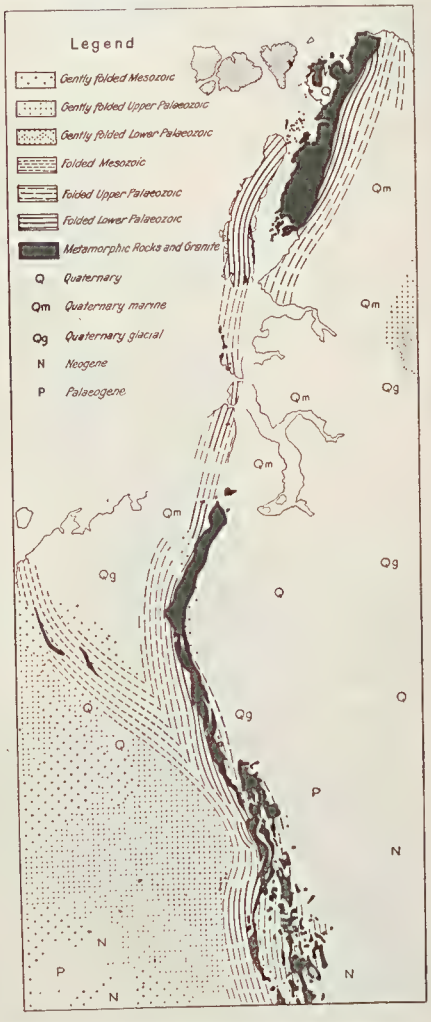

FIG. 16.—Novaya Zemlya Oroclines restored.

orocline, and show a convergence towards that point (see Fig. 13). The angle subtended at the orocline is 13°. It will be found presently that the Kara Rift subtends about 6°, leaving about 9° to be accounted for by the Barents Sea, the Khatanga depression and Davis Strait. This would seem to be of the right order of magnitude. It will be shown later that the north and south sides of the East Greenland depression are lines of strong transcurrent displacement (the northern boundary is De Geer's Line of Wegmann, 1948). The writer will show elsewhere that this trapezoidal shape with two opposing tension boundaries and two complementary transcurrent boundaries, is a characteristic form of disjunctive basin, and that this pattern recurs many times on the earth's surface.

In order to recognise the tensional opening of the Kara Sea, it is first necessary to examine the Novaya Zemlya and Pai Khoi oroclines, which will be found to be part of the larger pattern of the Alaskan orocline.

Novaya Zemlya and Pai Khoi Oroclines

The northern continuation of the Urals makes a right-angled elbow bend to the north-west into the Pai Khoi mountains for 400 km. into

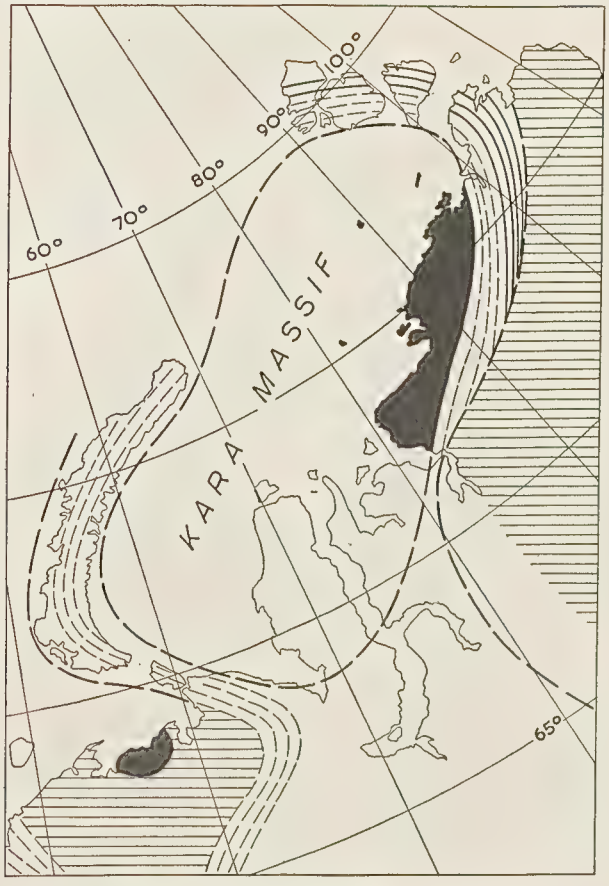

FIG. 17.—Kara Massif according to Umbgrove.

Novaya Zemlya. Here there is a further right-angled elbow to the north-east, a trend which continues thence for 400 km. Fig. 15 shows the structure of this region as traced from the one to five million Geological Map of the U.S.S.R. prepared for the International Geological Congress (1937). These inflections fall within the morphological category and are of the dimensions of structures to be tested as oroclines.

Fig. 16 shows the picture as it would be if the two elbow bends were straightened. The mere unbending, of course, produces a simpler tectonic picture. But the Novaya Zemlya link now reveals the crystalline rocks and Upper Palaeozoic folds of the Byrranga Mountains and Taimyr Peninsula as the direct continuation of the Urals. The resulting greater Urals would sweep in a simple bow from the Aral Sea to the Laptev Sea, a distance double their present length.

This raises the question of what underlies the Kara Sea. According to the orocline interpretation the Kara Sea should be a simatic basin, the tension rift due to the double orocline and morphologically similar to the Bay of Biscay and Arabian Sea, though modified in shape owing to the second orocline. However, Umbgrove (1947, plate 5) has postulated a Kara Massif of crystalline rocks, now foundered, to account for the rim ranges of the Pai Khoi, Novaya Zemlya, and the Taimyr Peninsula (Fig. 17). But there is no real evidence for a Kara massif, and his rim ranges are in part contrary to fact. For the arc of Caledonian and Hercynian folds shown by Umbgrove to swing from the Byrranga mountains northwards and north-westwards into the islands of Severnaya Zemlya is not in agreement with the geological map. Umbgrove seems to follow Leuchs, whose reconstruction is in agreement with old topographic maps (Bartholomew 1931, p. 53); but this topography is revised in later maps (Bartholomew 1950, p. 63). Moreover, the trends given by Umbgrove cut across the trends on the U.S.S.R. 1 : 5,000,000 geological map. The old crystalline rocks, shown by Umbgrove along the Kharitona Lapteva coast only as far as Taimyr Bay, in fact continue eastward without change of trend to Cape Pyretra, and the Hercynian folds south of these crystalline rocks, also continue eastwards without break to the Laptev Sea. (Compare Figs. 15 and 17.)

Although the Kara Sea is for the most part very shallow, it is difficult to avoid the conclusion that it consists largely of a thick delta of Tertiary and Recent sediments. This would also apply to the greater part of the Yamal Peninsula. The only outcrops in this area are marine Quarternary sediments; moreover, this area is the only outlet for the Ob-Irtysh and Yensei river systems which together drain all the country between the Urals, the Altai, and Lake Baikal, an area approximately twice as large as the Mississippi catchment. It would indeed be surprising if there is not an accumulation of sediments in the Kara Sea at least equal to that about the mouth of the Mississippi.

The assumption that the Kara Sea basin then consists of young sediments resting on deep ocean bottom is in agreement with the morphology of the region, and all available geological data. The interpretation of the Pai Khoi-Novaya Zemlya inflections as a double orocline is therefore consistent with everything that is known about this region, and greatly simplifies the tectonic picture. The complementary relation of the Pai Khoi and Novaya Zemlya oroclines repeats the relation of

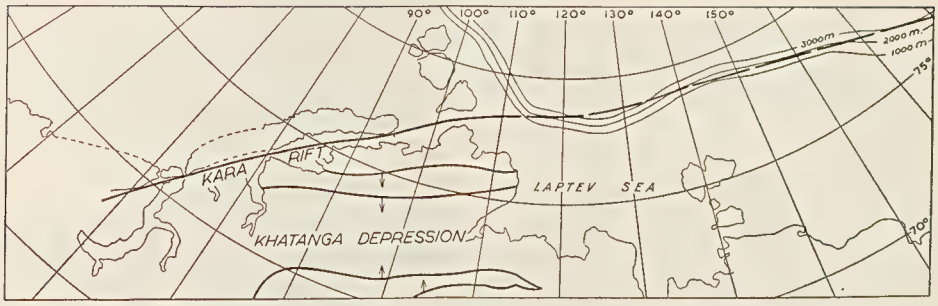

FIG. 18.—Tension structures associated with the Kara Rift.

the Baluchistan and Punjab oroclines. Each pair has produced a crank-like pattern and the two must be restored *pari passu*.

As in the previous examples discussed, there is ample evidence of second order tension with the same direction as the alleged Kara rift (Fig. 18). The Khatanga depression is a fault trough let down into old shield rocks of the Siberian platform thereby separating off the Taimyr Peninsula. Parallel faults are shown on the one to five million geological map along the south side of Taimyr block. The Khatanga depression is largely occupied by marine Quaternary sediments, but the faulting seems to have been active since the Mesozoic. The Kara rift is collinear with the northern edge of the continental shelf of eastern Siberia (compare Figs. 14 and 18), and the southern side of the Khatanga depression is collinear with the general trend of the North Siberian coast. This would seem to be a fault coast because old fold belts strike directly into it.

If these interpretations are correct the Kara Sea is a tensional rift behind the Novaya Zemlya diothesis, and is part of the distributed tension zone associated with the Alaskan orocline. This raises the question of the age of the double orocline in the Novaya Zemlya belt. The Alaskan orocline is presumably Mesozoic and early Tertiary; the Urals are Late Variscan, and so presumably are the Novaya Zemlya folds. But, according to the above interpretation, the *flexing* at least of the Novaya Zemlya trends would scarcely be older than early Mesozoic. However, another possibility is that the Alaskan orocline has been moving since the Palaeozoic (see the discussion below of the relation of the Alaskan transcurrent movement and the Glen Fault of Scotland). For comparison, the San Andreas fault of California has been moving consistently since the Jurassic (Hill and Dibblee 1952) and any earlier movement is not recognisable owing to lack of reference points.

Summary of Primary Tension Complementary to the Alaskan Orocline

Reverting to Figs. 13 and 14 it is now clear that the simple 30° tension rift sector of the Arctic basin and the North Atlantic Ocean, together with distributed tensional rifts of Baffin Bay, and the Greenland, Barents and Kara seas, are geometrically complementary to and radial from the Alaskan orocline and constitute the primary tension demanded by the geometry of that great bend.

It is not surprising that a rift as large as that which formed the Arctic and North Atlantic oceans should not be a single simple fracture.

The distribution of tension is unlikely to have been uniform over such an area. More important here, perhaps, was the lack of uniformity of the continental material. For the fractures seem to have followed largely the weak zones of earlier Palaeozoic fold belts, and as these did not run exactly in the line of maximum tension, echelon splinter fractures resulted (Fig. 14).

Second Order Tension Associated with the Alaskan Orocline

In the cases of the Pyrenean and Baluchistan oroclines, there were clear cut subsidiary tension structures, particularly on the larger continental block. The same is true of the Alaskan orocline, though here the echelon splinter pattern of the main rift indicates that the subsidiary tension fractures tend to merge with the primary fractures.

Thus, the Khatanga rift valley may be regarded as the expression of subsidiary tension on the larger block (compare Figs. 13 and 14). The Lisbon fault (Figs. 3, 11 and 12) is clearly of this type. The Rhine Graben (Figs. 11 and 12) is also radial from the Alaskan orocline and integrates perfectly with this great tension system. Many writers have referred to the East Russian depression between the White and Caspian Seas as a belt of stretching of the continent. This has the position and character of a radial tension sag associated with the Alaskan orocline and the opening of the North Atlantic ocean. There can be no doubt then that there were in fact tensional conditions both major and minor on the trends and at the time required by the orocline interpretation of the Alaskan bend.

Transcurrent Displacement Associated with the Alaskan Orocline

The Pyrenean and Baluchistan oroclines were found to be associated with transcurrent movement in the same sense as the rotation. Similar evidence is present in the case of the Alaskan orocline. I shall discuss elsewhere the whole question of this and other megashears. It will then be shown that this megashear follows the south-eastern side of the Greenland block, and the northern edge of the Barents-Kara shelf from Spitsbergen to the Tamyr Peninsula, then continues across east Siberia to the *Fossa magna* of Honshu thence on to the Mariannas (see Fig. 13). This will be found to be the principal line of slippage between the Asian and North American masses. Meanwhile I wish to confine the present discussion to the orocline concept, and to resist the temptation to dwell on the cognate structures. Suffice it to point out that the relative displacement of the American block has the same sense with respect to Asia as its rotation about the Alaskan orocline, as is required by physical theory.

Parallel to this primary Laurasian megashear there are other major transcurrent faults. The Iceland megashear springs from the Pai Khoi-Novaya Zemlya oroclines and from the south-eastern boundary of the East Greenland disjunctive basin (see Fig. 13). Intense transcurrent displacement believed to be of Upper Palaeozoic age has been established in the northern British Isles (Kennedy 1946, and Leedal and Walker, 1954). The Glen fault is believed to have been moved 65 miles and the Barnsmore faults have throws of two or three miles. It is perhaps significant that the trend and sense of movement of these mapped faults agree with the Iceland Megashear.

Restoration of the Alaskan Orocline

In order to reverse the strains implied by the Alaskan orocline, it is necessary to carry out the following operations concurrently:—

(i) Reverse the transcurrent displacement of about 1000 km. along the Laurasian megashear.

(ii) Close up the distributed tension of the East Greenland basin, the Kara Sea, Davis Strait, the Barents Sea, and the associated subsidiary stretchings.

(iii) Close the primary rift sector by rotating America through 28° about the Alaskan orocline.

The result is shown in Fig. 19. Thus, the reversal of the visible strains of the earth's crust reproduces Du Toit's Laurasia without Schuchert's North-Atlantic misfit and without Wegener's dilemna of widening the Bering Strait as he moved America towards Europe. The palaeogeographic arguments used by Du Toit to build his Laurasia have not been used in the present synthesis. The palaeogeographic and tectonic analyses stand therefore as independent corroborative testimonies.

By comparing figures 13 and 19, it will be found that each block is assumed to extend out to the 2000 m. isobath. The boundary rifts and megashears follow this line closely. Statistical grounds for adopting the 2000 m. isobath as arbitrary boundary of continental blocks are given elsewhere (Carey 1955).

The shape of the deep sea basin between Newfoundland Banks and Greenland (Fig. 13) suggests that the Greenland block may originally have fitted against the Labrador shelf with Cape Farewell against the northern re-entrant of the Banks east of St. John. However, this would in turn imply the existence of a megashear along the north coast of Baffin Island and along Lancaster Sound, Barrow Strait and McClure Strait. Whereas this might be so, there is no published evidence of it, so this first draft of the restoration of the Alaskan orocline omits it. But it should be borne in mind that even if the Alaskan orocline is valid, more data are necessary before all details of its associated fractures and displacements could be finally reconstructed.

Case for the Alaskan Orocline

The case for the reality of the Alaskan orocline may be summarised as follows:—

(1) There is a major change of direction of the trends of the marginal orogenic zone of North America. This bowed form must either have developed as such from the beginning or be an impressed strain.

(2) The Arctic basin is a triangular gap in the continental material; this gap is apical to the centre of the bend in the orogen. The gap is geometrically where it would be if the wheel is in fact an impressed strain. The angle of the gap agrees with the angle of change of trend.

(3) There exists clear evidence of tension on a continental scale, the tensional fractures being approximately radial to the centre of the alleged orocline. The tension is geometrically where it should be if the wheel in trends is in fact an impressed strain.

(4) There is evidence of transcurrent movement on a continental scale, of a kind which would probably be present if the alleged orocline is in fact an impressed strain.

(5) The palaeogeography of the parts presents a coherent whole under this interpretation. There is nothing in the palaeogeography on the negative side to contradict the configuration which results from the assumption that the wheel in trends is in fact an orocline—on the contrary the integrated palaeogeography gives this solution very strong support.

(6) The adoption of the orocline alternative and the restoration which is implied, *ipso facto* result in comprehensive and unexpected integration of diverse facts. Structures such as the Rhine Graben, Lisbon Fault, White Sea-Caspian depression, the inflections of Novaya Zemlya, Khatanga

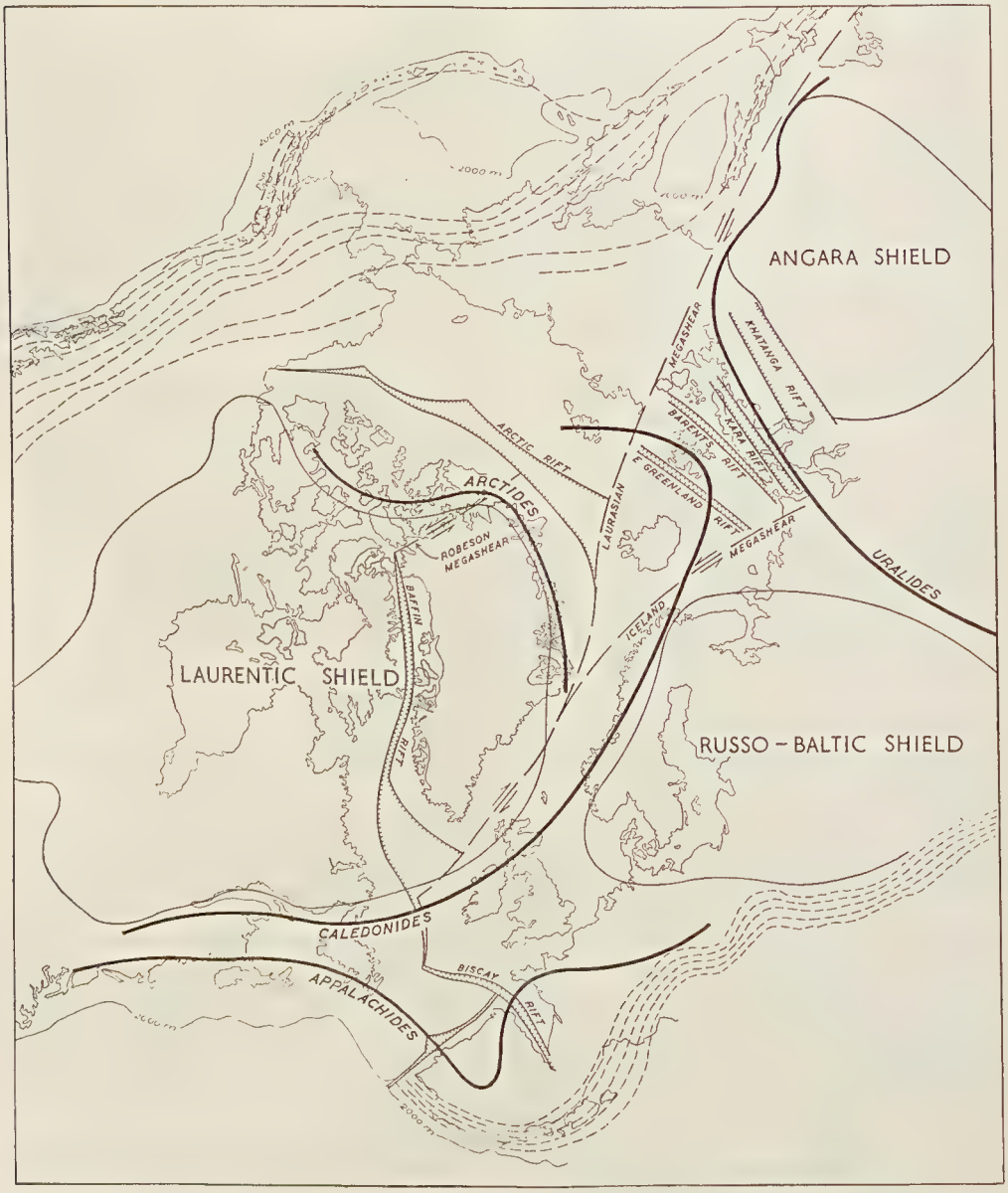

FIG. 19.—The Alaskan Orocline restored.

rift valley, the Arctic and North Atlantic basins, and the Robeson Channel megashear, all become integrated as parts of a single movement. The Urals become part of a structure twice as large. Shuchert's two classic criticisms of this part of the Wegener hypothesis, the "Atlantic misfit", and the objection that if America is moved closer to Europe the Bering Strait must be widened equally, both vanish.

(7) The Pyrenean, Baluchistan and Alaskan oroclines each independently reproduces parallel phenomena—an inflection in the orogens, apical rift sector, consistent major and minor tension phenomena, transcurrent displacement in the same sense, coherent palaeogeography, integration of all regional structures large and small, and automatic unexpected solution of diverse anomalies. It is surely in the highest degree improbable that any one such concurrence should be fortuitous. The triple repetition of such concurrences is surely strong ground for accepting the induction that all three bends are in fact oroclines.

Six European Oroclines

Excluding the Pyrenees and Ebro folds already discussed, the pattern of the fold systems of Alpine age is shown in Fig. 20. This pattern immediately discloses six great loops in the fold trends; the Riff, Sicilian, Ligurian, Carpathian, and Transylvanian loops, each of which causes a bend in the fold trends of about 180°, and the Hellenic bend through about a right angle. In accordance with the stated purpose of this investigation let us see the consequences of assuming that these bends are all oroclines—impressed strains due to folding in plan. Fig. 21 shows the pattern which results. Nothing has been done in going from Fig. 20 to Fig. 21 except straighten the six loops on the assumption that they are impressed strains. The trend plan allows two solutions according as the Apennines are interpreted as a continuation of the Atlas through the Sicilian orocline or of the Alps through the Ligurian orocline. Whichever be adopted, there can be no doubt that this is a greatly more probable picture than the existing twisted tangle, whether we look at it from the point of view of palaeogeography or of tectonics and the implied stress systems.

Tectonic Pattern in the Alpine Belt

The present distribution of the directions of compression and intense shortening gives a hopelessly chaotic pattern, quite impossible to resolve into any rational stress system. Consider for example the Riff arc, which wheels through 180°. The 1 : 1,000,000 Geological map of Spain (1951) shows clearly that the directions of the fold axes and the two structural zones of the Alpine geosyncline continue smoothly right round the loop. To form this structure *in situ* demands an intense local system of forces acting radially through two quadrants from a point in the Mediterranean some 70 km. east of Gibraltar, or an equally improbable centripetal system. An even more local and intense centre of forces is demanded in the plains of Milan, the centre of the Ligurian orocline, and another in the Tyrrhenian Sea and still another in the Hungarian plain. In addition, other bilateral compressive forces, equally intense, are demanded to account for the various straight connecting belts, which have trends which box the compass (e.g., the Apennine trend is at right

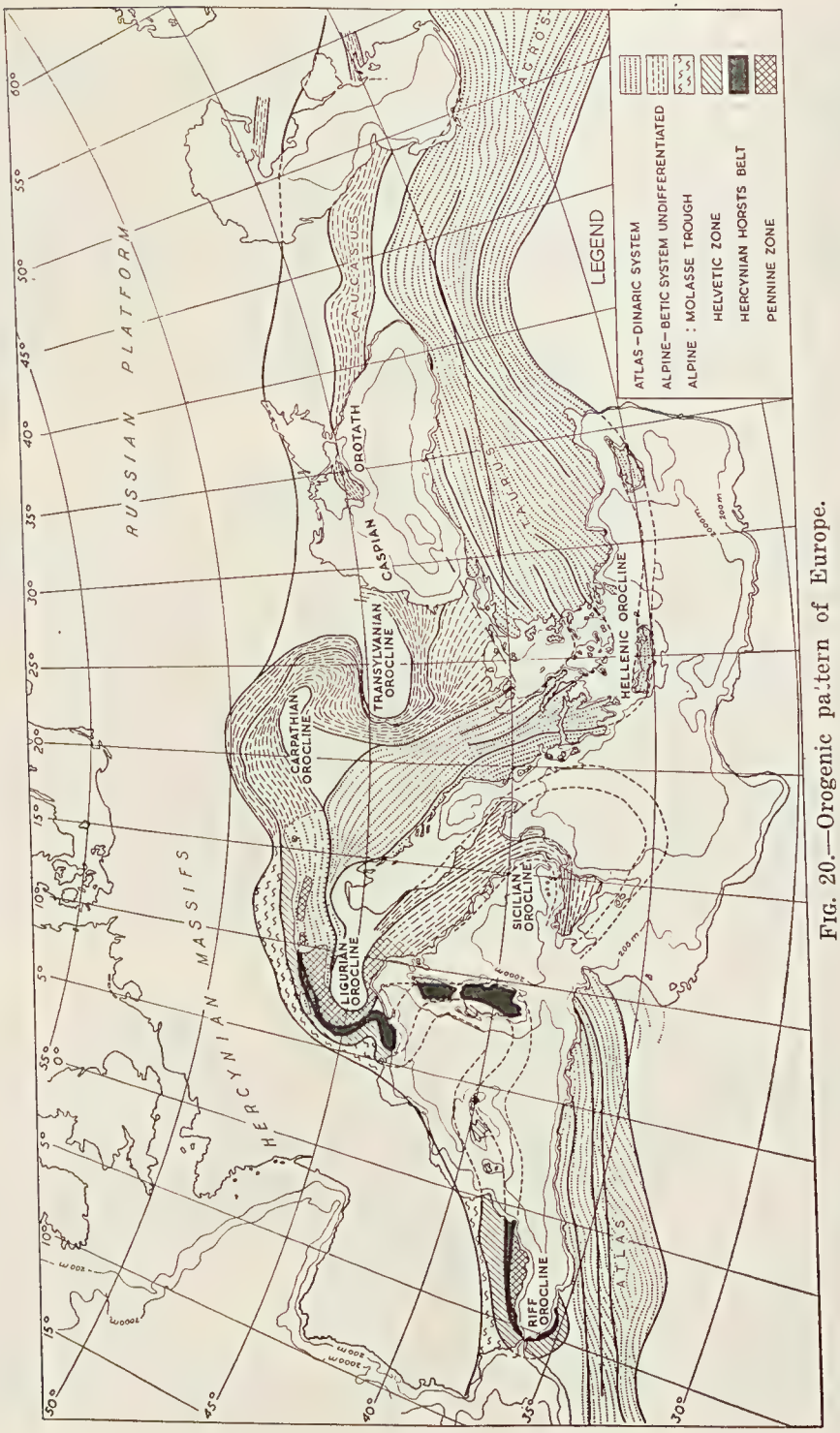

FIG. 20.—Orogenic pattern of Europe.

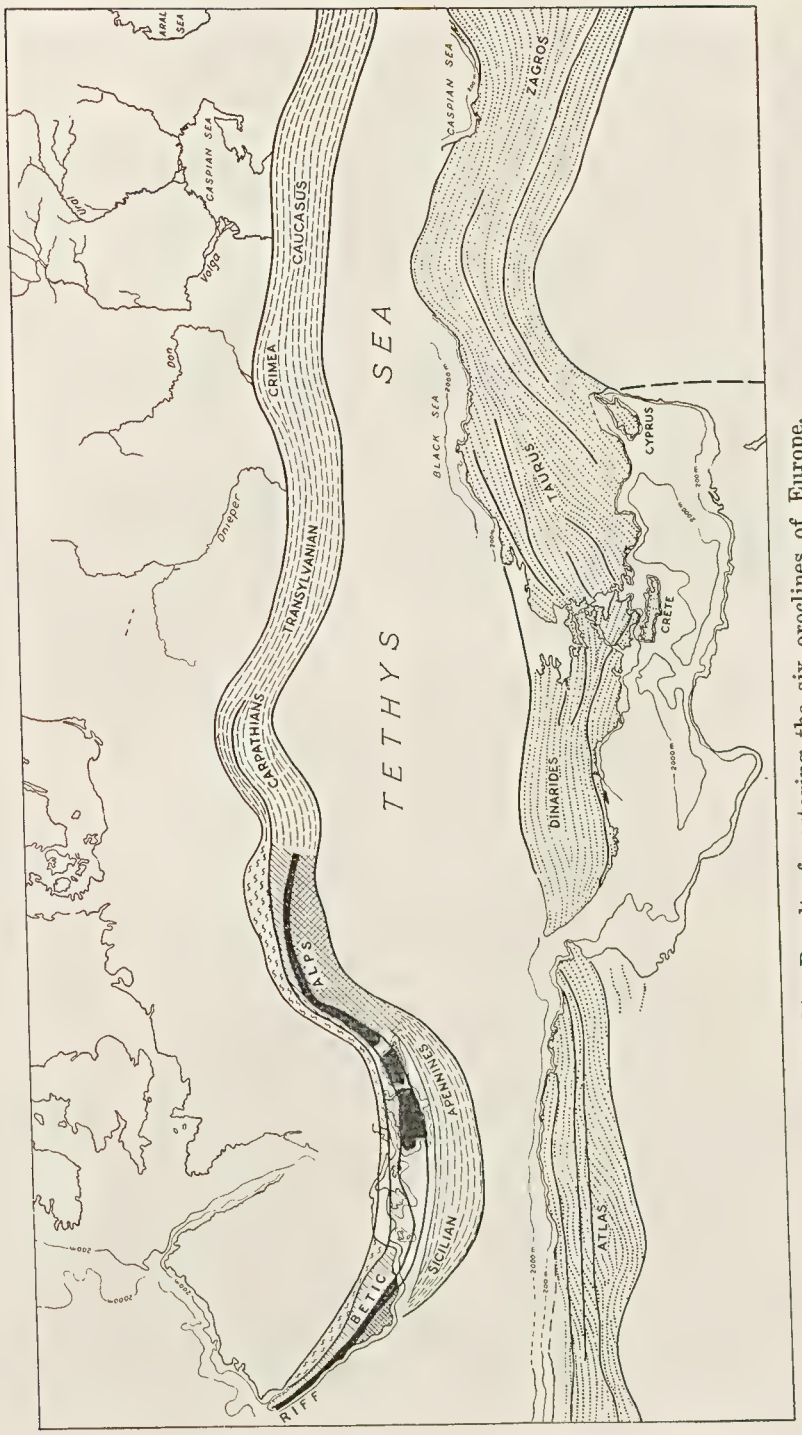

FIG. 21.—Result of restoring the six oroclines of Europe.

angles to the Alpine trend). It is difficult or impossible to offer any coherent stress system at all, still more so to relate such a confused tangle to any global tectonic pattern. Yet these foldings were clearly part of a revolution which expressed itself in every quarter of the globe.

Once the oroclines are straightened, however, the strain pattern becomes extremely simple—two marginal orogenic belts facing each other across the Tethys. Observe (Fig. 21) how the great Tethys emerges unsought from the orocline restoration! The Tethys was the first world-scale palaeogeographic conception ever to be recognised by geologists. What a complicated business it is to reconstruct it from the tangle of trends and cross-trends all the way from Spain to Burma! Yet, if one makes the single induction that the visible bends in the great orogenic belts are impressed strains, undo them, and there *is* the Tethy's, simple and entire! It seems that wherever an orocline is restored an unexpected and unsought solution to a problem of greater scale is granted.

Facies Distribution in Alpine Belt

Let us review first the palaeogeography of the Alpine geosyncline in the Western Mediterranean where the orocline concept implies that it has been intensely disrupted by large scale diotheses. In the type area the Alpine orogen has been divided into distinctive zones from north-west to south-east:—

(*a*) The Hercynian shelf, the stable mass against which the Alps are folded.
(*b*) The Molasse zone—the lowland of the Swiss plain which consists of a trough of Neogene sediments.
(*c*) The Helvetic zone—a synclinorial belt of fold and thrust mountains made up from the intense compression of marine shelf deposits on the northern side of the main geosyncline.
(*d*) The Horst zone—an anticlinorial belt exposing horsts of the pre-Mesozoic basement, which are thrust across the Helvetic zone.
(*e*) The Pennine zone—fold and thrust mountains made up from the shortening of the sediments of geosynclinal facies.
(*f*) The Dinaric zones, which in the eastern Alps are thrust across the top of the horst and Pennine zones.

As the fold belts are approached from the north-west the Molasse zone, which is marked by wavy broken lines on Fig. 20, is the first continuous structure with an Alpine trend. From the Swiss plain it extends eastwards along the Upper Danube valley to Vienna, and thence round the Carpathian arc where its northern margin becomes less clearly defined. South-westwards from Geneva this lowland continues down the lower Rhone Valley to the sea. It is again clearly recognisable as the Guadalquivir trough from Valencia to Seville.

North-westwards from this boundary trough emerge the Palaeozoic platforms of Western Europe—the Spanish Meseta, the central massif of France, Ardennes, Vosges, Black Forest, and the Harz and Bohemian Mountains—the whole showing a swell and basin pattern. The structures in these massifs are characteristically oblique to the Alpine trend and

they successively strike into it. In some places local elements with Alpine trend appear on the northern margin of the Molasse trough, such as, for example, the Jura Mountains, though even here a branch of the Neogene lowland runs up the Saone valley behind the Jura.

The Helvetic zone hatched on Fig. 20 is clearly defined in the Western Alps, and continues to the sea near Toulon and Marseilles. Rocks of this facies without basement horsts also occur in the north-west corner of Sardinia, and in the north-eastern belt of the Betic Cordillera of Spain, whence they continue across the Straits of Gibraltar around the Riff arc. In the Balearic Islands, the north-eastern belt of Majorca and Ibiza may well belong here.

The anticlinorial zone of basement horsts is shown in solid black in Fig. 20. The black zone is the strip in which they occur, for they are not continuous. In the Alps the horsts are represented in the Aar, St. Gotthard, Aiguilles Rouge, Mont Blanc, and Grenoble massifs, the core of the Maritime Alps, and the Maures massif between Cannes and Toulon. Corsica and Sardinia are largely made up of granite and Palaeozoic rocks whose tectonic characters fit in with this zone. So in part do the Balearic islands, especially Minorca, which exposes inliers of Carboniferous rocks. The Spanish Coastal belt between Gibraltar and Cartagena including the Sierra Nevada is largely composed of basement rocks, mainly Pre-Cambrian crystallines of the Estrado Series, Silurian strata, and granites. However, much of this is allochthonous, and represents the cores of nappe sheets of the Pennine zone. The belts are much more complex in detail than is suggested by Fig. 20, but the regional distribution pattern which is significant to the present discussion is not affected by this complexity. This belt of pre-Triassic rocks continues across the Straits of Gibraltar round the coastal front of the Riff loop as far as the Bay of Alhucemas.

The Pennine zone of the Alps, shown cross-hatched in Fig. 20, with its lustrous schist facies and ophiolites, continues without interruption round the Ligurian loop past Genoa, Spezia and Leghorn into Tuscany. The north-eastern corner of Corsica, and much of the Betic Cordillera of Spain also belongs to this facies.

The Dinaric zone, shown in stipple in Fig. 20, is entirely allochthonous in the Alps proper. Its roots are in a tightly squeezed zone which extends eastwards from near Turin and the Lombardy foothills. It lies like a crumpled blanket over the eastern Alps with outlying remnants on the western Alps; the Dent Blanche nappe and the Pre-Alps on the shores of Lake Geneva may belong here. The Pennine zone shows through this sheet in the Engadine, High Tauern, and possibly the Semmering windows. The eastern boundary of the allochthonous Dinaric sheet has not been clearly identified.

Thus far I have summarized the distribution of the facies elements of the Alpine geosyncline as they exist to-day. As such, they make a hopelessly chaotic picture—palaeogeographically and diastrophically. If any facies is followed there are offsets, trend changes and wide gaps occupied by deep sea, which could scarcely be regarded as containing the same facies. These gaps have mild positive gravity anomalies, not strong negative ones as they would have if they were foundered segments. Once the oroclines are restored, the Alpine geosyncline from the Carpa-

thians to the Riff becomes a normal geosyncline with its foreland, foreland depression, miogeosynclinal belt with calcareous facies, geanticlinal ridge of basement inliers, and deep eugeosynclinal trough with greywacke facies, ophiolites, younger granites, and absence of limestones. The north-west corner of Sardinia has close facies resemblance to the north-east corner of Spain against which the restoration places it. Indeed so close is this resemblance that the Sardinian rocks are commonly classified as " Andalusian " facies. It should be emphasised that this integration is achieved without any selective placing of the fragments. Merely straighten the oroclines where they fall, closing the triangular rift gaps of the Ligurian and Tyrrhenian Seas (compare their morphology in Fig. 20 with the Bay of Biscay and the Arabian Sea), and the disrupted Alpine geosyncline goes together again into a comprehensible unity. This integration becomes thus an independent confirmation of the probable validity of the orocline induction.

Relation of European Oroclines to the Cratons

The six European oroclines differ from the Alaskan and Baluchistan oroclines in that they are developed on diotheses. Where an orogen remains in contact with the associated craton any orocline developed in it must be convex towards the craton, and it is accompanied by a triangular rift gap radial from the orocline. However, where a diothesis has occurred and the orogen has been pulled free from the craton with a disjunctive basin between the orogen and the craton, oroclines may be either convex or concave towards the craton, and they may not be accompanied by rupture of the craton. Orotaths are, however, likely under these circumstances. Such free orogens are analogous to allochthonous folds of vertical sections. The European oroclines are of this type, and many more examples will be found, commonly with associated orotaths. These will be described in due course.

Welding of the Riff Orocline

Let us examine those places where the orocline interpretation implies the welding of masses formerly widely separated—the Riff zone to North Africa, and the Dinaric belt to the Alps and the south-eastern Carpathians.

Consider first the Riff zone. Enough is known of the geology on either side of the Straits of Gibraltar to make it certain that the fold belts of the Spanish Sierra Nevada and Betic Cordillera continue across the Straits of Gibraltar and wheel round eastwards as the Riff Cordillera of Spanish Morocco. This was recognised by Habernicht (1881) and adopted by Suess (1885), and, as Bailey (1953) points out, although various contrary opinions have been put forward (e.g., Kober, Staub, *et al.*), " increasing knowledge has proved them unacceptable ". The 1 : 1,000,000 geological map of Spain (1951) shows clearly that the directions of the fold axes and two zones of the Alpine geosyncline (the Helvetic and geanticlinal horst zones) wheel continuously and smoothly round the loop, and Bailey (*loc. cit*) has recently repeated that the intense horizontal displacements and nappes are similarly developed around the arc.

The structural continuity of the Betic and Riff Cordillera implies that the Riff, now part of North Africa, must have taken part in any rotation of Spain and that its welding to Africa could not be older than early Tertiary. Just where the join is to be looked for is not established on the information available. However, it would be at least as far inland as an arc through Larache, Alcazarquivir and Uazan, thence continuing parallel to the Riff fold trends to emerge on the Mediterranean on the western side of Cape Tres Forcas. Morphologically this whole Riff arc, which is so closely related to the Betic arc, is like a graft stuck on the Atlas orogen. It has therefore been treated as part of Spain and separated from Africa when the rotation of the Iberian Peninsula was reversed. This leaves the Atlas as a simple normal fold belt (Fig. 21).

Welding of the Dinaric Belt

The line from the foothills of Lombardy near Milan to near the junction of the Mura and Drava Rivers north-east of Zagreb, which marks the weld of the Dinaric belt to the Alps proper, is one of the most tightly compressed zones of thrusting in the Alpine region. In addition, nappes which spring from this confused part of the Dinaric zone are described as having been thrust over the eastern Alps, concealing the Helvetic and Pennine nappes of the Alps proper, except where they may be seen through the Engadine and High Tauern windows. Likewise, the implied weld between the southern Dinarides and the Stara Planina Ranges of Bulgaria is marked by a zone of strong overthrusting which runs from near Belgrade to near Salonika. These facts are in agreement with the proposed reconstruction though they might agree also with other hypotheses. They are recorded merely as checks rather than as supporting evidence.

The Hellenic orocline is a right-angled bend rather than a continuous loop, and the fact that it is interrupted by the sea, some of it fairly deep, suggests that there has been radial tensional stretching as well as bending. When this is straightened and closed up, and combined with the

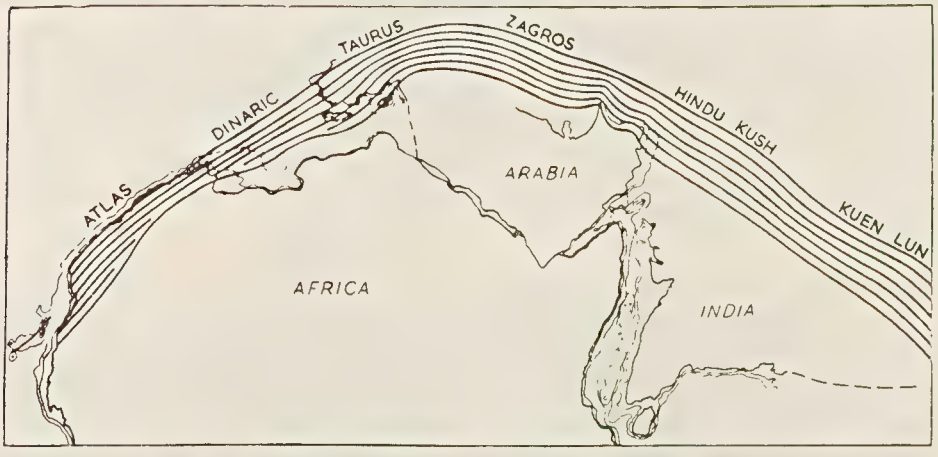

FIG. 22.—Tethyan portion of Gondwanaland resulting from reversing European and Baluchistan oroclines.

Baluchistan orocline movements, the Atlas, Dinarides, Taurus, Zagros, and Himalayas form a simple continuous belt to the Shan States—one hundred degrees of arc or 7000 miles (Fig. 22). This integration is another independent achievement of the orocline concept.

Dobrudja, Crimea, and Caucasus

The very extensive Neogene and Quaternary sedimentation of the northern parts of the Caspian and Black Seas obscures the relation of the Crimea and Caucasus to the Russian foreland. However, the gaps between the Dobrudja, Crimea, Caucasus, and the Aklal Tekke mountains across the Caspian, suggest that this is an orotath or stretched orogen which would be closed up by the straightening of the Carpathian and Transylvanian oroclines. This interpretation has been adopted provisionally in Fig. 21. This would imply that the Russian platform does not extend much further south than Odessa, Rostov, and the Magyshlak Peninsula, and that the alluvial plains further south conceal a former disjunctive sea as deep as the Black Sea, which formerly linked the Black and Caspian Seas north of the Caucasus.

Criticisms of the European Reconstruction

Although the simple assumption that all the great bends are oroclines clearly succeeds to an astonishing degree, there are anomalies. In the first place correlations have been made between the Apennines and both the Atlas and the southern Dinarides. On the other hand it is of course wholly possible that such resemblances are fortuitous and express similar facies rather than identity. Again, the Apennines are reported to be overthrust towards the north-east, which is contrary in sense to the Alpine and Betic thrusts with respect to the restored orogen.

The solution to these anomalies may lie in the interpretation of the Apennines as the continuation of the Atlas and not of the Ligurian arc. The continuity of the southern orogen would then be: Atlas, tensional gap, Sicily, Sicilian Orocline, Apennines, an attenuated orotath round the Po valley to the Dinarides. The northern orogen would be Alps, Ligurian orocline into the Tuscan Apennines, thence with several tensional gaps via Elba, Corsica, Sardinia, Balearides to the Betic and Riff zones. This picture is close to Stille's synthesis and is quite reconcilable to the orocline concept. However, in making the initial test of the orocline induction the writer deliberately followed out what seemed to be the simplest interpretation of the morphology of the trends to discover where the induction might lead.

Summary of the European Oroclines

The single induction that the six great wheels in the trend lines of Europe are impressed strains produces tectonic coherence from tectonic chaos. The Alpine structures fall logically into a grander structure which involves the whole of Asia. The Alpine geosyncline makes palaeogeographic sense for the first time. The great Tethys emerges from the straightened Alpine folds, as indeed it must, for nothing is more certain than that the reversal of Alpine movements should reproduce the Tethys.

Role of The Orocline Concept in Geotectonics

The present paper is but the beginning of a new approach to geotectonics. A few examples of oroclines have been discussed in some detail. Several more have been sketched more briefly. Altogether, twelve oroclines have been depicted in the diagrams. There are 25 such major bends of orogenic belts on the face of the globe, all with more than 30° of deviation. Not one of them yields contradictory results or improbable palaeogeography if it be assumed that the bend is in fact an orocline. In every case there is evidence supporting the orocline interpretation, and, as in the cases herein discussed, unexpected solutions to other problems appear.

In spite of the universality of this result, there seems to be no *a priori* reason to assume that all orogenic belts were necessarily straight or only gently curved. Each orocline must justify itself on its own internal evidence.

At the outset of this discussion it was pointed out (Fig. 1, &c.) that deformation in plan of large amount should be expected in all orogenic terrains. There is no logical reason why orogenic movements should only (or even commonly) involve purely parallel movements, as has been implicitly assumed in current tectonic thinking. The orocline is one possible type of such deformation in plan. But there are others, such as stretching, disjunctive rifting, and transcurrent displacement. Logically all of these should be looked for, with magnitudes of displacement comparable with orogenic shortenings, i.e., hundreds of km. The writer has followed up this induction, and has found that there is evidence, as convincing as that presented herein in regard to the orocline, indicating that structures of each of these types, and of the magnitudes stated, do in fact exist, and that with the oroclines, they are the first order structures of the globe. This evidence will be presented in due course.

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A Systematic List of the Mollusca of Tasmania, Australia

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Abstract

This "List" offers an up-to-date revision of Tasmanian Molluscan systematics. The aim in preparation has been to take advantage, as far as possible, of all the research done since the "Checklist" of W. L. May (1921), and to include every mollusc at present known from Tasmania. The list is designed to be used in conjunction with the "Illustrated Index" of W. L. May (1923). A new sub-genus, *Hisseya-gibbula* nov. with type *Littorina hisseyana* Tenison Woods 1876 is introduced, and new names have been provided for shells apparently wrongly named in the "Index". These are *Ethminolia mayi* sp. nov. and *Zalipais laseroni* sp. nov.

Introduction

During the thirty years which have elapsed since the publication of the "Checklist" and "Illustrated Index" by W. L. May (1921-1923) a considerable transformation has taken place in molluscan systematics. The study of the molluscan radula or "lingual ribbon" has provided the basis for Professor Thiele's "Handbuch" (1931) setting out the systematic arrangement now in general use. The recent remarkable book "Australian Shells" by the noted conchologist Miss Joyce Allan (1950) reveals the extent of the revision undertaken by Australian workers since the publication of Mr. May's memorable and pioneering "Index". Although the "Checklist" has become obsolete, it remains a useful reference work, while Mr. May's "Illustrated Index" will continue to provide the only work of its kind, a fitting monument to the memory of Tasmania's greatest conchologist.

The recent and very considerable contribution to the study of intertidal ecology in Tasmania by Dr. Eric Guiler, (1950, et seq.) reveals the need for further study of the mollusca in Tasmania, notably in the problems of correct nomenclature. The present list it is hoped, will further aid students of ecology through the difficult maze of molluscan systematics and the identification of species. Affinity of the Tasmanian Mollusca.

A relationship with the molluscan fauna of New South Wales has long been recognised. Recent workers have tended to place this relationship on a generic footing, although specific associations still exist amongst the fauna of the Continental Shelf of the East Coast. Similar remarks may be made concerning relationship with South Australia, while recog-

nising many more littoral resemblances. Recent work in Victoria has associated the exposed coast fauna of that State with Tasmania, which has for some years been granted sub-regional zoo-geographical status. Further afield, the Tasmanian molluscan fauna has been shown to have considerable affinity for that of New Zealand. Dr. H. J. Finlay (1926) discussing the matter, feels that the relationship can be regarded as of only recent geological age. The influence of the Notonectian current in transporting " shells " from Tasmanian sources to the Dominion has been referred to, it perhaps, would require a period of " low water level " with resultant shorter distances between coasts to be effective. If all factors be taken into account, then the evidence points to Pleistocene time as a possible key to the problem. Dr. Morton (1951) has demonstrated that the Siliquarid *Pyxipoma weldii* Tenison Woods is identical on both sides of the Tasman Sea, and further points to a logical means of transport in habitat and sub-littoral station. A New Zealand mollusc, *Amaurochiton glaucus* has established itself in these waters, introduced accidently by man. However, the mollusc known here as *Sypharochiton pellis-serpentis*, though believed to be distinct from the New Zealand species of that name on a regional basis only, evidently was not introduced here. Until the matter has been thoroughly investigated it seems desirable to retain the name *Sypharochiton maugeanus* Iredale and May for the Tasmanian shell, and this is advocated in the present list. A strong relationship exists between Tasmanian and New Zealand terrestial and fluviatile mollusca, which cannot be explained by consideration of Marine phenomena alone. This affinity extends also to Victoria.

Explanatory notes to the List of Mollusca.

The systematic arrangement adopted in the list is basically that advocated by Thiele (1931), however in certain instances more recent research by certain authors has provided some revision on a family basis of several groups. In pursuance of the policy of providing as up to date work as reasonable, the results obtained by these authors, where they appear of sufficient authority, have been adopted.

The genotype of each genus is shown in brackets alongside each generic name. Each species is preceded by a list number, by means of which it may be traced in the index. Again each species, where applicable, is followed by the generic name, in brackets, used in the origional description of the species. Following this, also in brackets, the number of the species in W. L. May's " Check List " and the plate and figure numbers from his Illustrated Index, are placed. Where these inclusions are absent it may be concluded, firstly, that the generic name at present in use is that used by the particular author in describing the species, and secondly the species has been recorded or confirmed since May's " Index ". Where a doubt is implied or has been expressed concerning a record or a figure in the Index this is indicated by a mark of interrogation.

Certain species have been recorded as additional to the Index from time to time (e.g. Robin, 1930), while certain also are now recorded for the first time. One of these of note is a form of *Pleurobranchus maculatus* Quoy and Gaimard, allied to *Pleurobranchaea dorsalis* Allan, identified by Miss Allan, and here recorded under the first name until further material is obtained.

New Names

No. 372a. *Ethminolia mayi* sp. nov.

Iredale (1924) renamed the New South Wales species formerly known as *Margarita angulata*, as *probabilis* Iredale. The type, figured by Iredale, from Twofold Bay is apparently distinct from the Tasmanian shell figured by May, Index pl. xviii, f. 21, which is named as above. A shell in the May Collection, South Australian Museum is named as type.

No. 398. *Zalipais laseroni* sp. nov.

The name *lissa Suter* 1908 has been in use for a Tasmanian shell which does not seem conspecific with that New Zealand species. As the Tasmanian shell is apparently unnamed, Mr. Charles Laseron's name is associated with it, with much pleasure. The type, figured by May, Index pl. xx, f. 24, is in the May Collection, South Australian Museum.

Hisseyagibbula subgenus nov.

Genotype no. 358., *Littorina hisseyana* Tenison Woods 1876. Related to *Notogibbula* it differs conchologically notably in the distinctive narrow umbilicus, the form of the aperture, while the protoconch is blunter. The species, *hisseyana* could not satisfactorily remain in the tropical genus *Calliotrochus* and it seems best to separate it sub-generically pending further study of the shell and animal.

Finally, through an unfortunate oversight it is necessary to mention that the *Scaphoda* (Tusk shells), where left to follow the *Cephalapoda* in the list, whereas that group, being the most specialised, are usually placed last.

A bibliography is provided for convenient reference.

Acknowledgments.

The leading Australian Conchologists have generously supplied reprints where these were available. I wish to thank Miss Joyce Allan of the Australian Museum, Miss Hope Macpherson of the National Museum Melbourne, and Messrs. T. Iredale, B. C. Cotton, South Australian Museum, C. F. Laseron, and C. J. Gabriel, all of whom have helped in this way, or have loaned or identified specimens. I am particularly grateful to Mr. Iredale for his encouragement and advice, to Miss Allan for her help with the arrangement of the *Nudibranchia*, to Miss Macpherson for her very considerable help and advice, while Mr. Cotton has gone to some trouble to supply information on various species in the May collection at my request, adding useful notes.

I am much indebted to Mr. H. M. Hale, Director, South Australian Museum, for the loan of specimens of *Marginella* and *Coxiella* from the May Collection, South Australian Museum; to Dr. W. Bryden, Director, Tasmanian Museum, for the loan of specimens in his care; to Mr. Currall and Mr. Ellis, Director and Assistant Director respectively, Queen Victoria Museum, Launceston for the use of the collection in that Museum, the generosity of all these gentlemen enabling me to pursue a policy of examining as many shells as possible. I wish to thank Mr. F. Ellis, for his very generous help in finding journals, references and specimens for me, and Mr. A. Burke of Melbourne, who has sent reference books for a number of years, not without inconvenience to himself.

I am grateful to Professor V. V. Hickman, University of Tasmania, for his interest and a number of excellent specimens forwarded, and to my wife for her generous help in the preparation of the index to the list of molluscs.

Class: PELECYPODA

Order: PRIONODESMACEA

Sub-order: Palaeoconcha

Family: Solemyidae

Solemya Lamarck 1818 (*australis* Lamarck)
1. *australis Lamarak* 1818

Sub-order: Taxodonta

Super-family: NUCULACEA

Family: Nuculidae

Pronucula Hedley 1902 (*decorosa* Hedley)
2. *decorosa* Hedley 1902 (1, pl. 1, f. 3)
3. *mayi* Iredale 1930 (cancellata Cotton 1930)
4. *hedleyi* Pritchard and Gatliff 1904 (*Nucula*) (2, pl. 1, f. 2)
5. *micans* Angas 1878 (*Nucula*) (3, pl. 1, f. 3)

Ennucula Iredale 1931 (*obliqua* Lamarck)
6. *beachportensis* Verco 1907 (*Nucula*) (4, pl. 1, f. 4)
7. *obliqua* Lamarak 1819 (*Nucula*) (5, pl. 1, f. 5)

Family: Ledidae

Scaeoleda Iredale 1929 (*crassa* Hinds)
8. *crassa* Hinds 1843 (*Nucula*) (6, pl. 1, f. 7)

Ledella Verrill and Bush 1897 (messanensis Verrill and Bush)
9. *miliacea* Hedley 1902 (*Leda*) (7, pl. 1, f. 8)

Propeleda Iredale 1924 (*ensicula* Angas)
10. *ensicula* Angas 1877 (*Leda*) (8, pl. 1, f. 9)

Poroleda Hutton 1893 (*lanceolata* Hutton)
11. *spathula* Hedley 1915 (9, pl. 1, f. 10)

Super-family: ARCACEA

Family: Arcidae

Arca Linne 1758 (*noae* Linne)
Barbatia Gray 1842 (*barbata* Linne)
12. *pistachia* Lamarck 1819 (16, pl. 2, f. 1)
13. *squamosa* Lamarck 1819 (17, pl. 2, f. 3)

Destacar Iredale 1936 (*metella* Hedley)
14. *metella* Hedley 1917 (18, pl. 2, f. 2)

Anadara Deshayes 1830 (*antiquata* Linne)
15. *trapezia* Deshayes 1840 (19, pl. 2, f. 4)

Family: Limopsidae

Limopsis Sassi 1827 (*aurita* Brocchi)
16. *eucosmus* Verco 1907 (10, pl. 1, f. 11)
17. *penelevis* Verco 1907 (11, pl. 1, f. 13)
18. *tenisoni* Tenison Woods 1877 (12, pl. 1, f. 12)

Pleurodon Wood 1840 (*ovalis* Wood)
19. *concentrica* Verco 1907 (13, pl. 1, f. 6)

Lissarca E. A. Smith 1877 (*rubrofusca* E. A. Smith)
20. *rhomboidalis* Verco 1907 (14, pl. 1, f. 14)
21. *rubricata* Tate 1886 (*Limopsis*) (15, pl. 1. f. 15)

Family: Glycymeridae

Glycymeris Da Costa 1778 (*glycymeris* Linne)
s.g. *Veletuceta* Iredale 1931 (*flammeus* Reeve)
22. *flammeus* Reeve 1843 (*Pectunculus*) (20, pl. 2, f. 5)
23. *radians* Lamarck 1819 (*Pectunculus*) (22, pl. 2, f. 7)

24. (*striatularis*) suspectus Iredale 1924 (23, pl. 2, f. 8)
25. *fossa* Iredale 1931 (24, pl. 2, f. 9)
s.g. *Tucetona* Iredale 1931 (*flabellatus* T. Woods)
26. *flabellatus* Tenison Woods 1877 (*Glycymeris*) (21, pl. 2, f. 6)

Family: **Philobryidae**

Cosa Finlay 1926 (*costata* Bernard)
27. *fimbriata* Tate 1898 (*Philobrya*) (25, pl. 2, f. 10)
28. *pectinata* Hedley 1902 (*Philobrya*) (26, pl. 2, f. 11)
29. *tatei* Hedley 1901 (*Philobrya*) (27, pl. 2, f. 12)
29a. *subpurpurea* May 1924 (*Philobrya*). King Island
Micromytilus Cotton 1931 (*crenatuliferus* Tate)
30. *crenatuliferus* Tate 1892 (*Myrina*) (28, pl. 2, f. 13)
Notomytilus Hedley 1916 (*ruber* Hedley)
31. *ruber* Hedley 1904 (*Philippiella*) (29, pl. 2, f. 14)

Sub-order: Schizodonta

Super-family: **PTERIACEA**

Family: **Vulsellidae**

Vulsella Bolten 1793 (*lingulata* Lamarck)
32. *Vulsella* Linne 1758 (*Mya*) (32, pl. 3, f. 3)
33. *spongiarum* Lamarck 1819

Family: **Pinnidae**

Atrina Gray 1847 (*nigra* Chemnitz)
34. *tasmanica* Tenison Woods 1876 (*Pinna*) (30, pl. 3, f. 1)

Family: **Pteriidae**

Electroma Stolickza 1871 (*smaragdina* Reeve)
35. *georgiana* Quoy and Gaimard 1835 (*Avicula*) (31, pl. 2, f. 15)

Super-family: **OSTRACEA**

Family: **Ostreidae**

Ostrea Linne 1758 (*edulis* Linne)
36. *virescens* Angas 1867 (33, pl. 3, f. 2)

Super-family: **NAIADACEA**

Family: **Propehyridellidae**

Sub-family: *Velesunionae*

Velesunio Iredale 1934 (*balonnensis* Conrad)
37. *shuttleworthi* Kuster 1855 (*Unio*) (155, pl. 9, f. 11)

Sub-family: *Propehyridellinae*

Rugoshyria Iredale 1934 (*parramattensis* Lea = *depressa* Lamarck)
38. (*depressa*) *sodalis* Iredale 1934 (156, pl. 9, f. 12)

Super-family: **TRIGONACEA**

Family: **Trigonidae**

Neotrigonia Cossmann 1912 (*pectinata* Lamarck)
39. *margaritacea* Lamarck 1804 (*Trigonia*) (34, pl. 3, f. 4)

Sub-order: Isodonta

Super-family: **PECTINACEA**

Family: **Pectinidae**

Notovola Finlay 1926 (*novaezelandiae* Reeve)
40. *meridionalis* Tate 1886 (*Pecten*) (35, pl. 3, f. 5)
Equichlamys Iredale 1929 (*bifrons* Lamarck)
41. *bifrons* Lamarck 1819 (*Pecten*) (39, pl. 3. f. 6)

Mimachlamys Iredale 1929 (*asperrimus* Lamarck)
42. *instar* Iredale 1925 (*Chlamys*) (37, pl. 3, f. 8)
43. *asperrimus* Lamarck 1819 (*Pecten*) (38, pl. 3, f. 7)
Scaeochlamys Iredale 1929 (*lividus* Lamarck)
s.g. *Belchlamys* Iredale 1929 (*aktinos* Petterd)
44. *aktinos* Petterd 1886 (*Pecten*) (36, pl. 3, f. 10)
Notochlamys Cotton 1930 (*anguineus* Finlay)
45. *tasmanicus* Adams and Angas 1863 (*Chlamys*) (40, pl. 3, f. 9)
Chlamydella Iredale 1929 (*favus* Hedley)
46. *favus* Hedley 1902 (*Cyclopecten*) (41, pl. 3, f. 11)
47. *obliquus* Hedley 1902 (*Cylopecten*) (42, pl. 3, f. 12)

Family: **SPONDYLIDAE**

Spondylus Linne 1758 (*gaederopus* Linne)
48. *tenellus* Reeve 1856 (43, pl. 3, f. 13)

Family: **LIMIDAE**

Austrolima Iredale 1929 (*nimbifer* Iredale)
49. *gemina* Iredale 1929 (44, pl. 3, f. 14)
Escalima Iredale 1929 (*murrayi* Smith)
50. *murrayi* Smith 1891 (*Lima*) (46, pl. 3, f. 16)
51. (*murrayi*) *maugeana* Iredale 1929
Limatula Wood 1839 (*subauriculata* Montagu)
52. *strangei* Sowerby 1872 (45, pl. 3, f. 15)

Super-family: **ANOMIACEA**

Family: **Anomiidae**

Monia Gray 1849 (*zelandica* Gray)
53. *ione* Gray 1849 (47, pl. 3, f. 17)

Sub-order: Dysodonta

Super-family: **MYTILACEA**

Family: **Mytilidae**

Mytilus Linne 1758 (*edulis* Linne)
54. *tasmanicus* Tenison Woods 1875 (48, pl. 4, f. 1)
55. *planulatus* Lamarck 1819 (49, pl. 4, f. 2)
Brachyodontes Swainson 1840 (*sulcatus* Lamarck)
56. *erosus* Lamarck 1819 (*Mytilus*) (50, pl. 4, f. 4)
57. *hirsutus* Lamarck 1819 (*Mytilus*) (51, pl. 4, f. 3)
58. *rostratus* Dunker 1856 (*Mytilus*) (52, pl. 4, f. 5)
Modiolus Lamarck 1799 (*modiolus* Linne)
59. *albicostus* Lamarck 1819 (*delinificus* Iredale 1924) (53, pl. 4. f. 6)
60. *spatula* Lamarck 1819 (*Modiola*) (55, pl. 4, f. 7)
61. *pulex* Lamarck 1819 (*modiola*) (59, pl. 4. f. 11)
62. *confusus* Angas 1871 (*Perna*) (=*pulex* L.?) (56, pl. 4, f. 9)
63. *lineus* Hedley 1906 (*Modiola*) (57, pl. 4, f. 12)
64. *nebulosus* Tenison Woods 1876 (58, pl. 4, f. 10)
Amygdalum Megerle and Muhlfeld 1811 (*arborescens* Chemnitz = *dendriticum* Muhlfeld)
65. *beddomei* Iredale 1924 (54, pl. 4, f. 8)
Musculus Bolten 1798 (*discors* Linne)
66. *barbatus* Reeve 1857 (*Lithodomus*) (60, pl. 4, f. 13)
67. *cumingianus* Reeve 1857 (*Lithodomus*) (61, pl. 4, f. 14)
68. *paulucciae* Crosse 1863 (*Crenella*) (62, pl. 4, f. 15)
Exosiperna Iredale 1929 (*scapha* Verco)
69. *scapha* Verco 1908 (*Arcoperna*) (64, pl. 4, f. 18)
Solamen Iredale 1924 (*rex* Iredale)
70. *recens* Tate 1896 (*Arcoperna*) (63, pl. 4, f. 17)

Super-family: **GAIMARDIACEA**

Family: **Gaimardiidae**

Neogaimardia Odhner 1924 (*rostellata* Tate)
71. *tasmanica* Beddome 1882 (*Modiolarca*) (65, pl. 4, f. 16)

Order: ANOMALODESMACEA

Super-family: LATERNULACEA

Section: *Eusiphonia*

Family: Laternulidae

Laternula Bolten 1798 (*anatina* Linne)
72. *creccina* Reeve 1860 (*Anatina*) (66, pl. 5, f. 1)
73. *tasmanica* Reeve 1860 (*Anatina*) (67, pl. 5, f. 3)

Family: Periplomidae

Offadesma Iredale 1930 (*angasi* Crosse and Fischer)
74. *angasi* Crosse and Fischer 1864 (*Periploma*) (68, pl. 5, f. 2)

Family: Pholadomyidae

Notomya Cotton 1931 (*tasmanica* Hedley and May)
75. *tasmanica* Hedley and May 1914 (*Pholadomya*) (74, pl. 5, f. 9)

Family: Thraciidae

Eximiothracia Iredale 1924 (*speciosa* Angas)
76. *myodoroides* E. A. Smith 1885 (*Thracia*) (70, pl. 5, f. 5)
77. *lincolnensis* Verco 1907 (*Thracia*) (69, pl. 5, f. 4)
78. *subalata* Gatliff and Gabriel 1910 (*Saxicava*) (210, pl. 12, f. 10)

Thraciopsis Tate and May 1900 (*angustata* Angas)
79. *peroniana* Iredale 1924 (72, pl. 5, f. 7)

Thracidora Iredale 1924 (*arenosa* Hedley)
80. *arenosa* Hedley 1904 (*Thraciopsis*) (71, pl. 5, f. 8)

Family: Myochamidae

Myochama Stutchbury 1830 (*anomioides* Stutchbury)
81. *anomioides* Stutchbury 1830 (75, pl. 5, f. 10)
82. *tasmanica* Tenison Woods 1878 (*Gouldia*) (76, pl. 5, f. 11)

Myodora Gray 1840 (*brevis* Sowerby)
83. *brevis* Sowerby 1829 (*Pandora*) (78, pl. 5, f. 13)
84. *albida* Tenison Woods 1876 (77, pl. 5, f. 16)
85. *complexa* Iredale 1924 (79, pl. 5, f. 14)
86. *pandoriformis* Stutchbury 1835 (*Anatina*) (80, pl. 5, f. 15)
87. *subalbida* Gatliff and Gabriel 1914 (81, pl. 5, f. 17)
88. *tasmanica* Tenison Woods 1875 (82, pl. 5, f. 12)
89. *elongata* May 1915 (73, pl. 5, f. 8)

Section: *Adelosiphonia*

Family: Pandoridae

Cleidothaerus Stutchbury 1830 (*albidus* Lamarck)
90. *albidus* Lamarck 1819 (*Chama*) (83, pl. 5, f. 18)

Super-family: CLAVAGELLACEA

Family: Clavagellidae

Humphreyia Gray 1858 (*strangei* A. Adams)
91. *strangei* A. Adams 1852 (*Aspergillum*) (84, pl. 5, f. 19)

Super-family: POROMYACEA

Family: Poromyidae

Ectorisma Tate 1892 (*granulata* Tate)
92. *granulata* Tate 1892 (86, pl. 6, f. 2)

Vertambitus Iredale 1930 (*vadosa* Hedley)
93. *tasmanica* May 1915 (*Verticordia*) (85, pl. 6, f. 1)

Family: Cuspidariidae

Cuspidaria Nardo 1840 (*cuspidata* Olivi)
94. *alta* Verco 1908 (87, pl. 5, f. 5)
95. *angasi* Smith 1885 (*Neaera*) (88, pl. 6, f. 3)

96. *brazieri* Smith 1885 (*Neaera*) (89, pl. 6, f. 4)
97. *exarata* Verco 1908 (90, pl. 6, f. 7)
98. *tasmanica* Tenison Woods 1875 (*Neaera*) (91, pl. 6, f. 6)

Order: TELEODESMACEA

Sub-order: Diogenodonta

Super-family: ASTARTACEA

Family: Crassatellidae

Eucrassatella Iredale 1924 (*kingicola* Lamarck)
99. *kingicola* Lamarck 1805 (*Crassatella*) (95, pl. 6, f. 11)
100. *verconis* Iredale 1936
Talabrica Iredale 1924 (*aurora* A. Adams and Angas)
101. *aurora* A. Adams and Angas 1863 (*Crassatella*) (92, pl. 6, f. 9)
Salaputium Iredale 1924 (*fulvidum* Angas)
102. *fulvidum* Angas 1871 (*Crassatella*) (94, pl. 6, f. 8)
Cuna Hedley 1902 (*concentrica* Hedley)
103. *concentrica* Hedley 1902 (97, pl. 6, f. 14)
104. *planilirata* Gatliff and Gabriel 1911 (134, pl. 8, f. 10)
Ovacuna Laseron 1953 (*atkinsoni* T. Woods)
105. *atkinsoni* Tenison Woods 1876 (96, pl. 6, f. 13)
Volupicuna Iredale 1936 (*delta* Tate and May)
106. *delta* Tate and May 1900 (*Cuna*) (98, pl. 6, f. 15)
Hamacuna Cotton (*hamata* Hedley and May)
107. *hamata* Hedley and May 1908 (*Cuna*) (99, pl. 6, f. 16)

Super-family: SPHAERIACEA

Family: Sphaeriidae

Sphaerinova Iredale 1943 (*macgillivrayi* Smith)
108. *lacusedes* Iredale 1943 (151, pl. 9, f. 8)
109. *tasmanica* Tenison Woods 1876 (*Cyclas*) (152, pl. 9, f. 9)
Australpera Iredale 1943 (*etheridgei* Smith)
110. *tasmanica* Tenison Woods 1876 (*Pisidium*) (154, pl. 9, f. 9)
111. *dulvertonensis* Tenison Woods 1876 (*Pisidium*) (153, pl. 9, f. 7)

Super-family: CYAMIACEA

Family: Cyamiidae

Cyamiomactra Bernard 1897 (*problematica* Bernard)
112. *mactroides* Tate and May 1900 (*Cyamium*) (150, pl. 9, f. 6)
113. *communis* Hedley 1905 (149, pl. 9, f. 5)

Super-family: CARDITACEA

Family: Condylocardiidae

Condylocuna Iredale 1936 (*projecta* Hedley)
114. *projecta* Hedley 1902 (*Condylocardia*) (115, pl. 7, f. 12)
Radiocondyla Iredale 1936 (*arezela* Iredale)
115. *arezela* Iredale 1936 (114, pl. 7, f. 11)
116. *pectinata* Tate and May 1900 (*Carditella*) (113, pl. 7, f. 10)
Condylocardia Bernard 1896 (*sanctipauli* Bernard)
117. *adelaideana* Cotton and Godfrey 1938 (112, pl. 7, f. 9)
118. *compressa* Hedley and May 1908 (*Cuna*) (111, pl. 7, f. 8)
119. *chapmani* Gatliff and Gabriel 1912

Family: Carditidae

Venericardia Lamarck 1801 (*imbricata* Lamarck)
120. *amabilis* Deshayes 1852 (*Cardita*) (102, pl. 6, f. 19)
121. *bimaculata* Deshayes 1852 (*Cardita*) (103, pl. 6, f. 20)
122. *gunni* Deshayes 1852 (*Cardita*)
123. *cavatica* Hedley 1902 (*Cardita*) (105, pl. 7, f. 1)
124. *columnaria* Hedley and May 1908 (101, pl. 7, f. 2)
125. *rosulenta* Tate 1886 (*Cardita*) (110, pl. 7, f. 7)
126. *exulata* E. A. Smith 1885 (108, pl. 7, f. 6)
Bathycardita Iredale 1925 (*raouli* Angas)

127. *raouli* Angas 1872 (*Venericardia*) (109, pl. 7, f. 5)
Vimentum Iredale 1925 (*dilectum* Smith)
128. *delicatum* Verco 1908 (*Venericardia*) (107, pl. 7, f. 4)
129. *dilectum* E. A. Smith 1885 (104, pl. 7, f. 3)
Cardita Bruguiere 1792 (*sulcata* Bruguiere)
130. *tasmanica* Tenison Woods 1876 (*Mytilicardia*)
Carditellopsis Iredale 1936 (*elegantula* Tate and May)
131. *elegantula* Tate and May 1901 (*Carditella*) (100, pl. 6, f. 17)

Super-family: CHAMACEA

Family: Chamidae

Chama Linne 1758 (*lazarus* Linne)
132. *fibula* Reeve 1846 (116, pl. 7, f. 13)

Super-family: LUCINACEA

Family: Lucinidae

Pexocodakia Iredale 1930 (*rugifera* Reeve)
133. *rugifera* Reeve 1850 (*Lucina*) (121, pl. 7, f. 18)
Notomyrtea Iredale 1924 (*botanica* Hedley)
134. *botanica* Hedley 1918 (*Lucina*) (124, pl. 8, f. 1)
135. *mayi* Gatliff and Gabriel 1911 (*Lucina*) (125, pl. 8, f. 2)
Divalucina Iredale 1936 (*cumingi* Adams and Angas)
136. *cumingi* Adams and Angas 1863 (125, pl. 8, f. 2)
Wallucina Iredale 1930 (*jacksoniensis* Smith)
137. *assimilis* Angas 1867 (*Loripes*) (123, pl. 7, f. 19)
138. *icterica* Reeve 1850 (*Lucina*)
Codokia Scopolli (*orbicularis* Linne)
139. *consettiana* Iredale 1930 (120, pl. 7, f. 17)
140. *crassilirata* Tate 1897 (*Lucina*) (118, pl. 7, f. 15)
141. *lacteola* Tate 1897 (*Lucina*) (119, pl. 7, f. 16)
142. *tatei* Angas 1878 (*Lucina*) (122, pl. 7, f. 14)
142a. *bella* Conrad 1834 (*Lucina*) (?) (117.....)

Family: Ungulinidae

Zemysia Finlay 1926 (*zelandica* Gray)
143. *tasmanica* Tenison Woods 1877 (*Gouldia*) (129, pl. 8, f. 6)
144. *globularis* Lamarck 1818 (*Lucina*)
145. *globulosa* Adams 1855 (*Diplodonta*) (128, pl. 8, f. 5)
Numella Iredale 1924 (*adamsi* Angas)
146. *adamsi* Angas 1867 (*Mysia*) (127, pl. 8, f. 4)

Family: Thyasiridae

Thyasira Lamarck 1818 (*flexuosa* Montagu)
Prothyasira Iredale 1930 (*peroniana* Iredale)
147. *adelaidiana* Iredale 1930 (130, pl. 8, f. 7)

Super-family: LEPTONACEA

Family: Leptonidae

Melliteryx Iredale 1924 (*acupunctum* Hedley)
148. *acupunctum* Hedley 1902 (*Erycina*) (131, pl. 8, f. 8)
149. *helmsi* Hedley 1915 (*Erycina*) (132, pl. 8, f. 9)
Kellia Turton 1822 (*rubra* Montagu)
150. *australis* Lamarck 1818 (*Cyclas*) (143, pl. 8, f. 19)
151. *miliaris* Philippi 1845 (144, pl. 8, f. 20)
Marikellia Iredale 1936 (*solida* Angas)
152. *solida* Angas 1877 (*Kellya*) (137, pl. 8, f. 13)
153. *rotunda* Deshayes 1855 (*Erycina*) (138, pl. 8, f. 14)
Lepton Turton 1822 (*squamosa* Montagu)
154. *trigonale* Tate 1879 (135, pl. 8, f. 11)
Mylitta d'Orbigny and Recluz 1850 (*deshayesi* d'Orbigny and Recluz)
155. *auriculata* E. A. Smith 1891 (145, pl. 9, f. 1)
156. *deshayesi* d'Orbigny and Recluz 1850 (146, pl. 9, f. 2)
157. *tasmanica* Tenison Woods 1876 (*Pythina*) (147, pl. 9, f. 3)
157a. *polita* May 1924 (King Island)

Legrandina Tate and May 1901 (*bernardi* Tate and May)
158. *bernardi* Tate and May 1901 (148, pl. 9, f. 4)
Borniola Iredale 1924 (*lepida* Hedley)
159. *radiata* Hedley 1905 (*Bornia*) (133, pl. 7, f. 20)
Notolepton Finlay 1926 (*antipoda* Filhol)
160. *rostellata* Tate 1889 (*Kellya*) (King Island) (136, pl. 8, f. 12)

Family: **Montacutidae**

Mysella Angas 1877 (*anomala* Angas)
161. *anomala* Angas 1877 (139, pl. 8, f. 15)
162. *donaciformis* Angas 1878 (140, pl. 8, f. 16)
163. *dromanaensis* Gatliff and Gabriel 1912 (*Montacuta*) (141, pl. 8, f. 17)
164. *lactea* Hedley 1902 (*Rochefortia*) (142, pl. 8, f. 18)

Sub-order: Cyclodonta

Super-family: **CARDIACEA**

Family: **Cardiidae**

Cardium Linne 1758 (*costatum* Linne)
165. *racketti* Donovan 1821 (159, pl. 9, f. 15)
166. *pulchellum* Gray 1840 (158, pl. 9, f. 14)
167. *cygnorum* Deshayes 1854 (157, pl. 9, f. 13)

Sub-order: Teleodonta

Super-family: **VENERACEA**

Family: **Veneridae**

Sub-family: *Dosiniinae*

Dosinia Scopoli 1777 (*africana* Gray)
168. *coerulaea* Reeve 1850 (*Artemis*) (160, pl. 9, f. 16)
169. *crocea* Deshayes 1853 (161, pl. 9, f. 18)
170. *grata* Deshayes 1853 (162, pl. 9, f. 17)
171. *victoriae* Gatliff and Gabriel 1914 (163, pl. 9, f. 19)
172. *euclia* Cotton and Godfrey 1938

Sub-family: *Meretricinae*

Paradione Dall 1909 (*ovalina* Lamarck)
173. *kingi* Gray 1827 (*Cytherea*) (167, pl. 10, f. 3)
174. *diemenensis* Hanley 1844 (*Cytherea*) (166, pl. 10, f. 4)
Sunemeroe Iredale 1930 (*adelinae* Angas)
175. *excavata* Hanley 1842 (*Cytherea*) (164, pl. 10, f. 1)

Sub-family: *Venerinae*

Bassina Jukes-Brown 1914 (*pachphylla* Jonas)
176. *pachyphylla* Jonas 1839 (*Venus*) (174, pl. 10, f. 11)
177. *disrupta* Sowerby 1853 (*Cytherea*)
Callanaitis Iredale 1917 (*yatei* Gray 1835)
178. *disjecta* Perry 1811 (*Venus*) (173, pl. 10, f. 10)
Placamen Iredale 1925 (*placidus* Philippi)
179. *placidum* Philippi 1844 (*Venus*) (172, pl. 10, f. 9)
Tawera Marwick 1927 (*spissa* Deshayes)
180. *gallinula* 1818 (*Venus*). *Lamarck.* (168, pl. 10, f. 5)
181. *lagopus* Lamarck 1818 (*Venus*) (169, pl. 10, f. 6)
181a. *spissa* Deshayes 1835 (*Venus*) (170, pl. 10, f. 7)
Chioneryx Iredale 1924 (*cardioides* Lamarck)
181b. *cardioides* Lamarck 1818 (*Erycina*) (171, pl. 10, f. 8)
Venerupis Lamarck 1818 (*perforans* Montagu)
182. *exotica* Lamarck 1818 (181, pl. 10, f. 18)
183. *diemenensis* Quoy and Gaimard 1835 (180, pl. 10, f. 17)
184. *crenata* Lamarck 1818 (179, pl. 10, f. 16)
185. *flabagella* Deshayes 1853 (*Tapes*) (182, pl. 10, f. 19)
186. *galactites* Lamarck 1818 (*Venus*) (183, pl. 11, f. 1)
187. *mitis* Deshayes 1853 (?) (184)

Katelysia Romer 1857 (*scalarina* Lamarck)
188. *scalarina* Lamarck 1818 (*Chione*) (178, pl. 10, f. 15)
189. *peroni* Lamarck 1818 (*Chione*)
190. *corrugata* Lamarck 1818 (*Chione*) (176, pl. 10, f. 13)
Eumarcia Iredale 1924 (*fumigata* Sowerby)
191. *fumigata* Sowerby 1853 (*Venus*) (177, pl. 10, f. 14)
Gouldiopa Iredale 1924 (*australis* Angas)
192. *australis* Angas 1865 (*Gouldia*) (165, pl. 10, f. 2)
Gomphina Moerch 1853 (*donacina* Chemnitz)
193. *undulosa* Lamarck 1818 (*Venus*) (175, pl. 10, f. 12)

Family: **Petricolidae**

Velargilla Iredale 1931 (*rubiginosa* Adams and Angas)
194. *rubiginosa* Adams and Angas 1863 (*Naranio*) (185, pl. 11, f. 2)

Super-family: **TELLINACEA**

Family: **Tellinidae**

Tellina Linne 1758 (*virgata* Linne)
(*Tellinota* Iredale 1936 (*roseola* Iredale)
195. *albinella* Lamarck 1818 (186, pl. 11, f. 3)
Pseudarcopagia Bertin 1878 (*victoriae* Gatliff and Gabriel)
196. *victoriae* Gatliff and Gabriel 1914 (*Tellina*) (190, pl. 11, f. 6)
197. *botanica* Hedley 1917 (189, pl. 11, f. 7)
Macoma Leach 1819 (*tenera* Leach)
198. *mariae* Tenison Woods 1876 (*Tellina*) (188, pl. 11, f. 5)
199. *deltoidalis* Lamarck 1818 (*Tellina*) (187, pl. 11, f. 4)
Apolymetus Salisbury 1929 (*meyeri* Dunker)
200. *umbonella* Lamarck 1819 (King Island) (?)

Family: **Semelidae**

Semele Schumacher 1817 (*proficua* Pultenay)
201. *exigua* A. Adams 1861 (191, pl. 11, f. 8)

Family: **Psammobiidae**

Psammobia Lamarck 1818 (*feroensis* Gmelin)
202. *kenyoniana* Pritchard and Gatliff 1904 (*Tellina*) (192, pl. 11, f. 10)
203. *livida* Lamarck 1818 (193, pl. 11, f. 9)
Flavomala Iredale 1936 (*biradiata* Wood)
204. *biradiata* Wood 1815 (*Solen*) (194, pl. 11, f. 11)

Super-family: **SOLENACEA**

Family: **Solenidae**

Solen Linne 1758 (*marginatus* Pultenay)
205. *vaginoides* Lamarck 1818 (195, pl. 11, f. 15)

Super-family: **MACTRACEA**

Family: **Mactridae**

Mactra Linne 1767 (*stultorum* Linne)
206. *australis* Lamarck 1818 (196, pl. 11, f. 12)
207. *pura* Deshayes 1853 (199, pl. 11, f. 16)
Austromactra Iredale 1930 (*contraria* Reeve)
208. *rufescens* Lamarck 1818 (*Mactra*) (200, pl. 11, f. 17)
Nannomactra Iredale 1930 (*jacksoniensis* Smith)
209. *jacksoniensis* E. A. Smith 1885 (*Mactra*) (197, pl. 11, f. 13)
Electromactra Iredale 1930 (*parkesiana* Hedley)
210. *flindersi* Cotton and Godfrey 1938 (198, pl. 11, f. 14)
Notospisula Iredale 1930 (*parva* Petitt)
211. *trigonella* Lamarck 1818 (*Mactra*) (201, pl. 12, f, 1)
Lutraria Lamarck 1799 (*lutraria* Linne)
212. *rhynchaena* Jonas 1844 (203, pl. 12, f. 3)
Anapella Dall 1895 (*triquetra* Hanley)
213. *pinguis* Crosse and Fischer 1864 (202, pl. 12, f. 2)

Family: **Amphidesmatidae**

Amphidesma Lamarck 1818 (*donacilla* Lamarck)
214. *angusta* Reeve 1854 (*Mesodesma*) (204, pl. 12, f. 4)
215. *cuneata* Lamarck 1818 (*Crassatella*) (205, pl. 12, f. 5)
216. *erycinaea* Lamarck 1818 (*Crassatella*) (206, pl. 12, f. 8)
217. *nitida* Deshayes 1850 (*Mesodesma*) (207, pl. 12, f. 7)

Sub-order: Asthenodonta

Super-family: **MYACEA**

Family: **Aloididae**

Aloidis Megerle 1811 (*sulcata* Lamarck)
218. *flindersi* Cotton 1930 (208, pl. 12, f. 8)

Family: **Hiatellidae**

Hiatella Daudin 1801 (*artica* Linne)
219. *australis* Lamarck 1818 (*Corbula*) (209, pl. 12, f. 9)
219a. *angasi* Angas 1865 (*Saxicava*)
Panope Menard 1807 (*glycimeris* Gmelin)
220. *australis* Sowerby 1833 (211, pl. 12, f. 11)

Family: **Gastrochaenidae**

Gastrochaena Spengler 1783 (*cuneiformis* Spengler)
221. *tasmanica* Tenison Woods 1876 (214, pl. 12, f. 14)

Super-family: **ADESMACEA**

Family: **Pholadidae**

Pholas Linne 1758 (*dactylus* Linne)
222. *australasiae* Sowerby 1849 (212, pl. 12, f. 12)
223. *obturamentum* Hedley 1893 (213, pl. 12, f. 13)

Family: **Teredidae**

Bankia Gray 1842 (*bipalmulata* Lamarck)
224. *gabrieli* Cotton 1934 (215, pl. 12, f. 15)

Class: (LORICATA =) CREPIPODA

Order: EOPLACPHORA

Family: **Lepidopleuridae**

Terenochiton Iredale 1914 (*subtropicalis* Iredale)
225. *matthewsianus* Bednall 1906 (*Lepidopleuris*) (228, pl. 14, f. 3)
Parachiton Thiele 1909 (*acuminatus* Thiele)
226. *columnarius* Hedley and May 1908 (*Lepidopleuris*) (226, pl. 14, f. 1)
227. *profundus* May 1923 (*Lepidopleuris*) (227, pl. 14, f. 2)

Order: MESOPLACOPHORA

Family: **Ischnochitonidae**

Ischnochiton Gray 1847 (*textilis* Gray)
s.g. Ischnochiton s. str.
228. *atkinsoni* Iredale and May 1916 (233, pl. 14, f. 8)
229. *contractus* Reeve 1847 (*Chiton*) (234, pl. 14, f. 9)
230. *falcatus* Hull 1912 (235, pl. 14, f. 10)
231. *lineolatus* Blainville 1825 (*Chiton*) (236-7, pl. 14, f. 11)
232. *elongatus* Blainville 1825 (Chiton) (pl. 14, f. 12)
233. *milligani* Iredale and May 1916 (239, pl. 14, f. 14)
234. *tateanus* Bednall 1897.
s.g. *Heterozona* Dall 1878 (*cariosus* Pilsbry)
235. *cariosus* Pilsbry 1892 (*Ischnochiton*) (245, pl. 15, f. 8)
236. *subviridis* Iredale and May, 1916 (246, pl. 15, f. 7)
237. *fruticosa* Gould 1846 (*Chiton*) (?)
s.g. *Autochiton* Iredale and Hull 1924 (*torri* Iredale and May)

238. *torri* Iredale and May 1916 (*Ischnochiton*) (241, pl. 15, f. 1)
s.g. *Ovatoplax* Cotton and Weeding 1939 (*mayi* Pilsbry)
239. *mayi* Pilsbry 1895 (*Ischnochiton*) (238, pl. 14, f. 13)
s.g. *Haploplax* Pilsbry 1894 (*smaragdinus* Angas)
240. *smaragdinus* Angas 1867 (*Lophyrus*) (240, pl. 14, f. 15)
241. *resplendens* Bednall and Matthews 1906 (*Ischnochiton*)
s.g. *Euporoplax* Iredale and Hull 1924 (*virgatus* Reeve)
242. *virgatus* Reeve 1847 (*Chiton*) (242, pl. 15, f. 2)
s.g. *Anisoradsia* Iredale and May 1916 (*mawlei* Iredale and May)
243. *mawlei* Iredale and May 1916 (*Ischnochiton*) (244, pl. 15, f. 4)

Ischnoradsia Shuttleworth 1853 (*australis* Sowerby)
244. *evanida* Sowerby 1840 (*Chiton*) (243, pl. 15, f. 3)
245. *novaehollandiae* Reeve 1847 (*Chiton*)

Family: **Callistochitonidae**

Callistelasma Iredale and Hull 1925 (*antiquus* Reeve)
246. *meridionalis* Ashby 1919 (*Callistochiton*) (248, pl. 15, f. 8)

Callistassecla Iredale and Hull 1925 (*mawlei* Iredale and May)
247. *mawlei* Iredale and May 1916 (*Callistochiton*) (247, pl. 15, f. 7)

Order: ISOPLACOPHORA

Family: **Cryptoconchidae**

Craspedoplax Iredale and Hull 1925 (*variabilis* H. Adams and Angas)
248. *variabilis* H. Adams and Angas 1864 (*Hanleya*) (260, pl. 16, f. 4)

Acanthochiton Gray 1821 (*fascicularis* Linne)
249. *bednalli* Pilsbry 1894 (*Acanthochites*) (252, pl. 15, f. 12)
250. *gatliffi* Ashby 1919 (254, pl. 15, f. 15)
251. *granostriatus* Pilsbry 1844 (*Acanthochites*) (255, pl. 15, f. 13)
252. *kimberi* Torr 1912 (*Acanthochites*) (256, pl. 15, f. 16)
253. *lachrymosus* May and Torr 1912 (*Acanthochitona*) (257, pl. 16, f. 1)
254. *sueurii* Blainville 1825 (*Chiton*) (259, pl. 16, f. 3)
255. *pilsbryi* Sykes 1896 (*Acanthochites*)
256. *johnstoni* Ashby 1923
257. *macrocystialis* Ashby 1924
258. *tatei* Torr and Ashby 1898 (*Achanthochites*)

Notoplax H. Adams 1861 (*speciosa* H. Adams)
259. *costata* H. Adams and Angas 1864 (*Acanthochites*) (253, pl. 15, f. 14)
260. *speciosa* H. Adams 1861 (*Cryptoplax*) (258, pl. 16, f. 2)
261. *subspeciosa* Iredale and Hull 1925
262. *extra* Iredale and Hull 1925
263. *mayi* Ashby 1922 (pl. 16, f. 5)
264. *spongialis* Ashby 1923

Bassethullia Pilsbry 1928 (*matthewsi* Pilsbry)
265. *glypta* Sykes 1896 (*Acanthochites*)

Family: **Cryptoplacidae**

Cryptoplax Blainville 1818 (*larvaeformis* Burrow)
266. *iredalei* Ashby 1923 (261)
267. (*iredalei*) *meridiana* Iredale and Hull 1925 (pl. 16, f. 7)
268. *striata* Lamarck 1819 (*Chitonellus*) (262, pl. 16, f. 6)

Family: **Plaxiphoridae**

Poneroplax Iredale 1914 (*costata* Blainville)
269. *albida* Blainville 1825 (*Chiton*) (249, pl. 15, f. 11)
270. *costata* Blainville 1825 (*Chiton*) (250, pl. 15, f. 10)

Kopionella Ashby 1919 (*matthewsi* Iredale)
271. *tasmanica* Ashby 1920 (251, pl. 15, f. 9)

Order: TELEOPLACOPHORA

Family: **Aulacochitonidae**

Loricella Pilsbry 1893 (*angasi* H. Adams)
272. *angasi* H. Adams 1864 (*Lorica*) (271, pl. 16, f. 15)

Aulacochiton Shuttleworth 1853 (*volvox* Reeve)
273. *cimolia* Reeve 1847 (*Chiton*) (270, pl. 16, f. 14)

Family: **Lepidochitonidae**

Paricoplax Iredale and Hull 1929 (*crecinna* Reeve)
274. *elongata* May 1919 (*Callochiton*) (230, pl. 14, f. 5)
275. *crocina* Reeve 1847 (*Chiton*) (232, pl. 14, f. 7)
Acutoplax Cotton and Weeding 1939 (*mayi* Torr)
276. *mayi* Torr 1912 (*Callochiton*) (231, pl. 14, f. 6)
Eudoxoplax Iredale and May 1916 (*inornata* Tenison Woods)
277. *inornata* Tenison Woods 1881 (*Chiton*) (229, pl. 14, f. 4)

Family: **Chitonidae**

Anthochiton Thiele 1893 (*tulipa* Quoy and Gaimard)
278. *calliozona* Pilsbry 1894 (*Chiton*) (264, pl. 16, f. 8)
279. *diaphora* Iredale and May 1916 (*Rhyssoplax*) (265, pl. 16, f. 9)
280. *orukta* Maughan 1900 (*Chiton*) (266, pl. 16, f. 10)
281. *tricostalis* Pilsbry 1894 (*Chiton*) (267, pl. 16, f. 11)
282. *aureomaculata* Bednall and Matthews (263 Juvenile of 267)
Amaurochiton Thiele 1893 (*olivaceous* Frembly)
283. *glaucus* Gray 1828 (*Chiton*) (269, pl. 16, f. 13)
Sypharochiton Thiele 1893 (*pellis-serpentis* Quoy and Gaimard)
284. *maugeanus* Iredale and May 1916 (268, pl. 16, f. 12)

Class: GASTROPODA

Sub-class: Streptoneura

Order: ASPIDOBRANCHIA

Sub-order: Archaeogastropoda

Super-family: ZEUGOBRANCHIA

Family: **Haliotidae**

Notohaliotis Cotton and Godfrey 1933 (*ruber* Leach)
285. *ruber* Leach 1814 (*Haliotis*) (296, pl. 18, f. 2)
Neohaliotis Cotton and Godfrey 1933 (*scalaris* Leach)
286. *emmae* Reeve 1846 (*Haliotis*) (295, pl. 18, f. 3)
Schismotis Gray 1856 (*excisa* Gray = *laevigata* Donovan)
287. *laevigata* Donovan 1808 (*Haliotis*) (294, pl. 18, f. 1)

Family: **Scissurellidae**

Scissurella D'Orbigny 1823 (*costata* d'Orbigny)
288. *ornata* May 1908 (273, pl. 17, f. 2)
Schizotrochus Monterosato 1877 (*crispata* Fleming)
289. *australis* Hedley 1903 (*Scissurella*) (272, pl. 17, f. 1)
Scissurona Iredale 1924 (*rosea* Hedley)
290. *rosea* Hedley 1904 (*Scissurella*) (274, pl. 17, f. 3)
Schismope Jeffrey 1856 (*striatula* Philippi)
291. *atkinsoni* Tenison Woods 1876 (*Scissurella*) (275, pl. 17, f. 4)
292. *beddomei* Petterd 1884 (276, pl. 17, f. 5)
293. *pulchra* Petterd 1884 (277, pl. 17, f. 6)

Family: **Fissurellidae**

Scutus Montfort 1810 (*ambiguus* Chemnitz)
294. *antipodes* Montfort 1810 (278, pl. 17, f. 7)
Tugalia Gray 1840 (*elegans* Gray)
295. *cicatricosa* A. Adams 1851 (279, pl. 17, f. 8)
Entomella Cotton 1945 (*candida* Adams)
296. *candida* A. Adams 1852 (*Emarginula*) (283 pl. 17, f. 12)
297. *bajula* Hedley 1913 (*Emarginula*) (282, pl. 17, f. 11)
298. *superba* Hedley and Petterd 1906 (*Emarginula*) (284, pl. 17, f. 13)
299. *curvamen* Iredale 1925 (*Emarginula*)
Montfortula Iredale 1915 (*rugosa* Quoy and Gaimard)
300. *conoidea* Reeve 1842 (280, pl. 17, f. 9)
301. *rugosa* Quoy and Gaimard 1834 (*Emarginula*)
Hemitoma Swainson 1840 (*tricostata* Swainson)

302. *subemarginata* Blainville 1819 (*Emarginula*) (281, pl. 17, f. 10)
Cosmetalepas Iredale 1924 (*concatenata* Crosse and Fischer)
303. *concatenata* Crosse and Fischer 1864 (*Fissurella*) (285, pl. 17, f. 14)
Amblychilepas Pilsbry 1890 (*javanicensis* Lamarck)
304. *javanicensis* Lamarck (*Fissurella*) (286, pl. 17, f. 15)
305. *omicron* Crosse and Fischer 1864 (*Fissurella*)
Sophismelepas Iredale 1924 (*nigrita* Sowerby)
306. *nigrita* Sowerby 1835 (*Fissurella*) (288, pl. 17, f. 17)
307. *crusis* Beddome 1883 (*Fissurella*) (287, pl. 17, f. 16)
Dolichoschisma Iredale 1940 (*producta* Adams)
308. *producta* Adams 1850 (*Macrochisma*)
Forelepas Iredale 1940 (*tasmaniae* Sowerby)
309. *tasmaniae* Sowerby 1866 (*Macrochisma*) (289, pl. 17, f. 18)
Zeidora Adams 1860 (*calceolina* Adams 1860)
310. *lodderae* Tate and May 1900 (290, pl. 17, f. 21)
311. *legrandi* Tate 1894 (291, pl. 17, f. 22)
Vacerra Iredale 1924 (*demissa* Hedley)
312. *demissa* Hedley 1904 (*Puncturella*) (292, pl. 17, f. 19)
313. *harrisoni* Beddome 1882 (*Puncturella*) (293, pl. 17, f. 20)

Sub-order: **Docoglossa**

Super-family: PATELLACEA

Family: **Patellidae**

Sub-family: *Patellinae*

Patellanax Iredale 1924 (*squamifera* Reeve)
314. *peronii* Blainville 1825 (*Patella*) (401, pl. 22, f. 15)
315. *chapmani* Tenison Woods 1875 (*Patella*) (400, pl. 22, f. 13)
316. *squamifera* Reeve 1855 (*Patella*) (401)
317. *alba* Tenison Woods 1877 (*Acmaea*)

Sub-family: *Nacellinae*

Cellana Adams 1869 (*sernica* Adams)
318. *tramoserica* Sowerby 1825 (*Patella*) (404, pl. 22, f. 17)
319. *solida* Blainville 1825 (*Patella*) (402, pl. 22, f. 16)
320. *rubraurantica* Blainville 1825 (*Patella*)

Family: **Lotiidae**

Patelloida Quoy and Gaimard 1834 (*rugosa* Quoy and Gaimard)
331. *petterdi* Tenison Woods 1876 (*Acmaea*) (397)
Collisellina Dall 1871 (*sacharina* Linne)
322. *latistrigata* Angas 1865 (*Patella*) (395, pl. 22, f. 9)
323. *submarmorata* Pilsbry 1891 (*Acmaea*)
Chiazacmea Oliver 1926 (*flammea* Quoy and Gaimard)
324. *flammea* Quoy and Gaimard 1834 (*Patelloida*) (394, pl. 22, f. 6)
325. *mixta* Reeve 1855 (*Patella*) (pl. 22, f. 8)
326. *conoidea* Quoy and Gaimard 1834 (*Patelloida*) (392, pl. 22, f. 11)
327. *mimula* Iredale 1924 (*Notoacmaea*)
Asteracmea Oliver 1926 (*illibrata* Verco)
328. *mellila* Iredale 1924 (*Parvacmea*) (399, pl. 22, f. 12)
Actinoleuca Oliver 1926 (*campbelli* Filhol)
329. *calamus* Crosse and Fischer 1864 (*Patella*) (390, pl. 22, f. 2)
Notoacmaea Iredale 1915 (*pileopsis* Quoy and Gaimard)
330. *mayi* May 1923 (*Patelloida*) (391, pl. 22, f. 3)
331. *petterdi* Tenison Woods 1876 (*Acmaea*) (397)
332. *scabrilirata* Angas 1865 (*Acmaea*) (pl. 22, f. 10?)
Conacmaea Oliver 1926 (*parviconoidea* Suter)
333. *corosa* Oliver 1926 (pl. 22, f. 4)
334. *subundulata* Angas 1865 (*Acmaea*) (398)
Subacmaea Oliver 1926 (*scopulina* Oliver)
335. *corrodenda* May 1919 (*Patelloida*) (393, pl. 22, f. 5)

Sub-order: Rhipidoglossa

Super-family: TROCHACEA

Family: Trochidae

Clanculus Montfort 1810 (*pharaonius* Linne)
s.g. *Macroclanculus* Cotton and Godfrey 1934 (*undatus* Lamarck)
336. *undatus* Lamarck 1816 (*Monodonta*) (307, pl. 18, f. 14)
s.g. *Euriclanculus* Cotton and Godfrey 1934 (*flagellatus* Philippi)
337. *flagellatus* Philippi 1848 (*Trochus*) (302, pl. 18, f. 9)
338. *limbatus* Quoy and Gaimard 1834 (*Trochus*) (303, pl. 18, f. 10)
s.g. *Isoclanculus* Cotton and Godfrey 1934 (*yatesi* Crosse)
339. *dunkeri* Kock 1843 (*Trochus*) (301, pl. 18, f. 8)
340. *aloysii* Tenison Woods 1876 (*Clanculus*) (308, pl. 18, f. 15)
341. var. *philomenae* Tenison Woods 1876 (*Clanculus*)
s.g. *Mesoclanculus* Iredale 1924 (*plebejus* Philippi)
342. *ochroleucus* Philippi 1853 (*Trochus*) (305, pl. 18, f. 12)
343. *plebejus* Philippi 1851 (*Trochus*) (306, pl. 18, f. 13)
s.g. *Clanculus* s. str.
344. *maugeri* Wood 1828 (*Trochus*) (King Island) (304, pl. 18, f. 11).
Phasianotrochus Fischer 1885 (*eximius* Perry)
345. *eximius* Perry 1811 (*Bulimus*) (311, pl. 18, f. 20)
346. *irisodontes* Quoy and Gaimard 1834 (*Trochus*) (313, pl. 18, f. 19)
347. *bellulus* Dunker 1845 (*Trochus*) (309, pl. 18, f. 18)
Thalotia Gray 1847 (*conica* Gray)
348. *conica* Gray 1827 (*Monodonta*) (311, pl. 18, f. 17)
Bankivia Krauss 1848 (*fasciata* Menke)
349. *fasciata* Menke 1830 (*Phasianella*) (312, pl. 18, f. 18)
Cantharidella Pilsbry 1889 (*picturata* Adams and Angas)
350. *picturata* Adams and Angas 1864 (*Gibbula*) (319, pl. 19, f. 6)
351. *tiberiana* Crosse 1863 (*Trochus*) (320, pl. 19, f. 7)
Austrocochlea Fischer 1835 (*constricta* Lamarck)
s.g. *Austrocochlea* s. str.
352. *constricta* Lamarck 1822 (*Monodonta*) (316, pl. 19, f. 2)
353. *obtusa* Dillwyn 1817 (*Trochus*) (317, pl. 19, f. 3)
s.g. *Fractarmilla* Finlay 1926 (*corrosa* Adams)
354. *concamerata* Wood 1828 (*Trochus*) (315, pl. 19, f. 1)
s.g. *Chlorodiloma* Pilsbry 1889 (*crinita* Philippi)
355. *adelaidae* Philippi 1849 (*Trochus*) (314, pl. 19, f. 4)
356. *odontis* Wood 1828 (*Trochus*) (318, pl. 19, f. 5)
Gibbula Risso 1826 (*magus* Linne)
s.g. *Notogibbula* Iredale 1924 (*coxi* Angas)
357. *coxi* Angas 1867 (*Gibbula*) (321, pl. 19, f. 8)
358. *tasmanica* Petterd 1879 (*Calliotrochus*) (325, pl. 19, f. 12)
s.g. *Hisseyagibbula* Kershaw antea (*hisseyana* T. Woods)
359. *hisseyana* Tenison Woods 1876 (*Littorina*) (323, pl. 19, f. 10)
Fossarina Adams and Angas 1863 (*patula* Adams and Angas)
s.g. *Minopa* Iredale 1924 (*legrandi* Petterd)
360. *legrandi* Petterd 1879 (*Fossarina*) (324, pl. 19, f. 11)
361. *petterdi* Crosse 1870 (*Fossarina*) (326, pl. 19, f. 13)

Family: Calliostomatiidae

Calliostoma Swainson 1840 (*conulum* Linne)
s.g. *Fautor* Iredale 1924 (*comptus* A. Adams)
362. *allporti* Tenison Woods 1876 (*Zizyphinus*) (330, pl. 19, f. 14)
363. *columnarium* Hedley and May 1908 (*Calliostoma*) (331, pl. 19, f. 17)
364. *hedleyi* Pritchard and Gatliff 1902 (*Calliostoma*) (332, pl. 19, f. 15)
365. *legrandi* Tenison Woods 1876 (*Zizyphinus*) (334, pl. 19, f. 16)
366. *retiarium* Hedley and May 1908 (*Calliostoma*) (337, pl. 19, f. 20)
s.g. *Salsipotens* Iredale 1924 (*armillatus* Wood = *meyeri* Philippi)
367. *armillatum* Wood 1828 (*Trochus*) (335, pl. 19, f. 18)
368. *nobile* Philippi 1846 (*Trochus*) (336, pl. 19, f. 19)
s.g. *Sinutor* Cotton and Godfrey 1935 (*incertum* Reeve)
369. *incertum* Reeve 1863 (*Zizyphinus*) (333, pl. 19, f. 21)
Astele Swainson 1854 (*subcarinatum* Swainson)
370. *subcarinatum* Swainson 1854 (338, pl. 19, f. 22)

Family: Umboniidae

Nanula Thiele 1924 (*tasmanica* Petterd)
371. *tasmanica* Petterd 1877 (*Margarita*)
372. *galbina* Hedley and May 1908 (*Gibbula*) (322, pl. 19, f. 9)
Ethminolia Iredale 1924 (*probabilis* Iredale)
373. *vitiliginea* Menke 1843 (*Trochus*) (329, pl. 18, f. 23)
373a. *mayi* Kershaw antea (327, pl. 18, f. 21)
Spectamen Iredale 1924 (*philippensis* Watson)
374. *philippensis* Watson 1881 (*Trochus*) (328, pl. 18, f. 22)

Family: Stomatellidae

Stomatella Lamarck 1816 (*imbricata* Lamarck)
375. *imbricata* Lamarck 1816 (297, pl. 18, f. 4)
Herpetopoma Pilsbry 1889 (*scabbriuscala* Adams and Angas)
376. *baccata* Menke 1843 (*Monodonta*) (*aspersa* Philippi) (341, pl. 19, f. 25)
377. *scabriuscula* Adams and Angas 1867 (*Euchelus*) (343, pl. 20, f. 1)
Vaceuchelus Iredale 1929 (*angulatus* Pease)
378. *profundior* May 1915 (*Euchelus*) (342, pl. 20, f. 2)
379. *ampullus* Tate 1893 (*Euchelus*)
Danilia Brusina 1865 (*tinei* Calcara)
380. *telebathia* Hedley 1911 (340, pl. 19, f. 24)
Basilissa Watson 1879 (*lampra* Watson)
381. *niceterium* Hedley and May 1908 (339, pl. 19, f. 23)

Family: Stomatiidae

Gena Gray 1847 (*nigra* Quoy and Gaimard)
382. *strigosa* Adams 1850 (298, pl. 18, f. 5)
383. *terminalis* Verco 1905 (299, pl. 18, f. 6)
Roya Iredale 1912 (*nutata* Hedley)
384. *nutata* Hedley 1908 (*capulus*) (300, pl. 18, f. 7)

Family: Liotiidae

Callomphala Adams and Angas 1864 (*lucida* Adams and Angas)
385. *lucida* Adams and Angas 1864 (*Neritula*) (?) (352, pl. 20, f. 11)
Cirsonella Angas 1877 (*australis* Angas)
386. *translucida* May 1915 (353, pl. 20, f. 12)
387. *weldii* Tenison Woods 1876 (354, pl. 20, f. 13)
Brookula Iredale 1912 (*stibarochila* Iredale)
388. *angeli* Tenison Woods 1876 (*Rissoa*) (355, pl. 20, f. 14)
389. *crebrisculpta* Tate 1899 (*Cyclostrema*) (356, pl. 20, f. 15)
390. *densilaminata* Verco 1907 (*Cyclostrema*) (357, pl. 20, f. 18)
391. *johnstoni* Beddome 1883 (*Cyclostrema*) (358, pl. 20, f. 17)
392. *nepeanensis* Gatliff 1906 (*Scala*) (359, pl. 20, f. 16)
393. *consobrina* May 1924 (King Island)
Lissotesta Iredale 1915 (*micra* Tenison Woods)
394. *contabulata* Tate 1899 (*Cyclostrema*) (360, pl. 20, f. 19)
395. *micra* Tenison Woods 1876 (*Cyclostrema*) (361, pl. 20, f. 20)
Conicella Laseron 1954 (*porcellana* Tate and May)
396. *porcellana* Tate and May 1900 (*Cyclostrema*) (362, pl. 20, f. 21)
Zalipais Iredale 1915 (*lissa* Suter)
397. *inscripta* Tate 1899 (*Cyclostrema*) (364, pl. 20, f. 23)
398. *bruniense* Beddome 1883 (*Cyclostrema*) (363, pl. 20, f. 22)
399. *laseroni* Kershaw antea (365, pl. 20, f. 24)
Elachorbis Iredale 1915 (*tatei* Angas)
400. *harriettae* Petterd 1884 (*Cyclostrema*) (366, pl. 20, f. 25)
Eudaronia Cotton 1945 (*jaffaensis* Verco)
401. *jaffaensis* Verco 1909 (*Cyclostrema*) (368, pl. 21, f. 2)
Liotella Iredale 1915 (*polypleura* Hedley)
402. *annulata* Tenison Woods 1874 (*Liotia*) (369, pl. 21, f. 3)
403. *compacta* Petterd 1884 (*Liotia*) (370, pl. 21, f. 5)
404. *petalifera* Hedley and May 1908 (*Liotia*) (371, pl. 21, f. 4)
Lodderia Tate 1899 (*lodderae* Petterd)
405. *lodderae* Petterd 1884 (*Liotia*) (372, pl. 21, f. 7)

Lodderena Iredale 1924 (*minima* Tenison Woods)
406. *minima* Tenison Woods 1878 (*Liotia*) (373, pl. 21, f. 6)
Pseudoliotia Tate 1898 (*micans* A. Adams)
407. *micans* A. Adams 1850 (*Cyclostrema*) (374, pl. 21, f. 8)
Munditia Finlay 1926 (*tryphenensis* Powell)
408. *tasmanica* Tenison Woods 1875 (*Liotia*) (379, pl. 21, f. 13)
409. *mayana* Tate 1899 (*Liotia*) (377, pl. 21, f. 11)
410. *subquadrata* Tenison Woods 1878 (*Liotia*) (378, pl. 21, f. 12)
Austroliotia Cotton 1948 (*botanica* Hedley)
411a. *botanica* Hedley 1915 (*Liotia*)
411. *australis* Kiener 1839 (*Delphinula*) (375, pl. 21, f. 9)
412. *densilineata* Tate 1899 (*Liotia*) (376, pl. 21, f. 10)
Charisma Hedley 1915 (*compacta* Hedley)
413. *arenacea* Pritchard and Gatliff 1902 (*Leptothyra*) (380, pl. 21, f. 15)
414. *josephi* Tenison Woods 1877 (*Cyclostrema*) (381, pl. 21, f. 14)
Argalista Iredale 1915 (*fluctuata* Hutton)
415. *rosea* Tenison Woods 1876 (*Monilea*)
416. *kingensis* May 1924 (King Island)
Crosseola Iredale 1924 (*concinna* Angas)
417. *carinata* Hedley 1903 (*Crossea*) (567, pl. 28, f. 15)
418. *cancellata* Tenison Woods 1878 (*Crossea*) (566, pl. 28, f. 13)
419. *concinna* Angas 1867 (*Crossea*) (568, pl. 28, f. 16)
420. *consobrina* May 1915 (*Crossea*) (569, pl. 28, f. 14)
Dolicrossea Iredale 1924 (*labiata* Tenison Woods)
421. *labiata* Tenison Woods 1876 (*Crossea*) (570, pl. 28, f. 17)
Microdiscula Thiele 1912 (*vanhoffeni* Thiele)
422. *charopa* Tate 1899 (*Cyclostrema*) (367, pl. 21, f. 1 ?)

Family: **Turbinidae**

Subninella Thiele 1929 (*undulatus* Solander)
423. *undulata* Solander 1786 (*Turbo*) (349, pl. 20, f. 8)
Euninella Cotton and Godfrey 1938 (*gruneri* Philippi)
424. *gruneri* Philippi 1846 (*Turbo*) (348, pl. 20, f. 7)
Bellastraea Iredale 1924 (*kesteveni* Iredale)
425. *kesteveni* Iredale 1924 (351, pl. 20, f. 10)
426. *sirius* Gould 1849 (*Turbo*)
Micrastraea Cotton 1938 (*aurea* Jonas)
427. *aurea* Jonas 1844 (*Trochus*) (350, pl. 20, f. 9)

Family: **Eutropiidae**

Phasianella Lamarck 1804 (*australis* Gmelin)
428. *australis* Gmelin 1788 (*Buccinum*) (344, pl. 20, f. 3)
Mimelenchus Iredale 1924 (*ventricosa* Swainson)
429. *ventricosa* Swainson 1822 (*Phasianella*) (345, pl. 20, f. 4)
Orthomesus Pilsbry 1888 (*variegata* Lamarck)
430. *angasi* Crosse 1864 (*Phasianella*)
Pellax Finlay 1926 (*huttoni* Pilsbry)
431. *rosea* Angas 1867 (*Eutropia*) (346, pl. 20, f. 6)

Super-family: **NERITACEA**

Family: **Neritidae**

Nerita Linne 1758 (*peleronta* Linne)
s.g. *Melanerita* Martens 1889 (*melanotragus* Smith)
432. *melanotragus* E. A. Smith 1884 (*Nerita*) (384, pl. 21, f. 18)

Family: **Phenacolepadidae**

Phenacolepas Pilsbry 1891 (*crenulata* Broderip)
433. *calva* Verco 1906 (*Scutellina*) (388, pl. 21, f. 22)

Super-family: **COCCULINACEA**

Family: **Cocculinidae**

Notocrater Finlay 1926 (*craticulata* Suter)
434. *tasmanica* Pilsbry 1895 (*Acmaea*) (385, pl. 21, f. 19)
Tectisumen Finlay 1926 (*clypidellaeformis* Suter)
435. *mayi* Finlay 1926 (386, pl. 21, f. 20)
436. *tasmanica* May 1919 (*Cocculinella*) (387, pl. 21, f. 21)

Order: PECTINIBRANCHIA
Sub-order: Taenoglossa
Section: *Platypoda*
Super-family: LITTORINACEA
Family: Littorinidae

Melaraphe Menke 1828 (*neritoides* Linne)
437. *praetermissa* May 1908 (*Littorina*) (405, pl. 22, f. 18)
438. *unifasciata* Gray 1827 (*Littorina*) (406, pl. 22, f. 19)
Pellilitorina Pfeiffer 1886 (*caliginosa* Gould)
439. *globula* Angas 1880 (*Amauropsis*) (624, pl. 30, f. 16)
Laevilitorina Pfeiffer 1886 (*setosa* Smith)
440. *mariae* Tenison Woods 1876 (*Rissoa*) (474, pl. 25, f. 5)
Larinopsis Gatliff and Gabriel 1916 (*turbinata* Gatliff and Gabriel)
441. *turbinata* Gatliff and Gabriel 1909 (*Larina*) (625, pl. 30, f. 17)

Family: Bembiciidae

Bembicium Philippi 1846 (*melanostoma* Gmelin)
442. *melanostomum* Gmelin 1789 (*Trochus*) (407)
442a. *planum* Quoy and Gaimard 1835 (pl. 22, f. 20)
443. *nanum* Lamarck 1822 (*Trochus*) (408, pl. 22, f. 21)
Riselopsis Kesteven 1902 (*varia* Hutton)
444. *mutabilis* May 1908 (409, pl. 22, f. 22)

Family: Acmeidae

Acmea Hartman 1821 (*lineata* Draparnaud)
445. *vincentiana* Cotton 1943 (511, pl. 26, f. 13)
446. *scalarina* Cox 1867 (*Truncatella*) (512, pl. 26, f. 14)

Super-family: RISSOACEA
Family: Coxiellidae

Coxiella E. A. Smith 1898 (*striatula* Menke)
447. *badgerensis* Johnston 1878 (*Pomatiopsis*) (513, pl. 26, f. 22)

Family: Paludestrinidae

Austropyrgus Cotton 1943 (*nigra* Quoy and Gaimard)
448. *nigra* Quoy and Gaimard 1834 (*Paludina*) (501, pl. 26, f. 3)
449. *petterdianus* Brazier 1875 (*Amnicola*)
450. *legrandi* Tenison Woods 1876 (*Bythinia*)
Rivisessor Iredale 1943 (*gunnii* Frauenfeld)
451. *gunnii* Frauenfeld 1863 (*Hydrobia*) (499, pl. 25, f. 29)
452. *turbinatus* Petterd 1889 (*Hydrobia*) (504, pl. 26, f. 5?)
453. *tasmanicus* Martens 1858 (*Hydrobia*) (503, pl. 26, f. 4)
454. *brownii* Petterd 1889 (*Potamopyrgus*) (496, pl. 26, f. 1)
Pupiphryx Iredale 1943 (*dyeriana* Petterd)
455. *dyeriana* Petterd 1879 (497, pl. 25, f. 27)
456. *smithii* Petterd 1889 (*Potamopyrgus*) (502, pl. 25, f. 28)
457. *elongatus* May 1921 (*Potamopyrgus*) (498, pl. 25, f. 30)
458. *dunrobinensis* Tenison Wood 1876 (*Bithynia*)
Phrantella Iredale 1943 (*marginata* Petterd)
459. *marginata* Petterd 1889 (*Potamopyrgus*) (500, pl. 26, f. 2)
Petterdiana Brazier 1896 (*tasmanica* Tenison Woods)
460. *paludinella* Reeve 1857 (*Littorina*) (509, pl. 26, f. 10)
Beddomena Iredale 1943 (*bellii* Petterd)
461. *bellii* Petterd 1889 (*Beddomeia*) (505, pl. 26, f. 6)
462. *lodderae* Petterd 1889 (*Beddomeia*) (508, pl. 26, f. 8)
463. *hullii* Petterd 1889 (*Beddomeia*) (506, pl. 26, f. 7)
Tasmaniella Ancey 1898 (*launcestonensis* Johnston)
464. *launcestonensis* Johnston 1879 (*Amnicola*) (507, pl. 26, f. 9)
465. *tumida* Petterd 1889 (*Beddomeia*)
466. *minima* Petterd 1889 (*Beddomeia*)
Valvatasma Iredale 1943 (*tasmanica* Tenison Woods)
467. *tasmanica* Tenison Woods 1876 (*Valvata*) (510, pl. 26, f. 11)

Family: Rissoidae

Estea Iredale 1915 (*zosterophila* Webster)
468. *approxima* Petterd 1884 (*Rissoa*) (440, pl. 24, f. 1)
469. *bicolor* Petterd 1884 (*Rissoa*) (441, pl. 24, f. 6)
470. *columnaria* Hedley and May 1908 (*Rissoa*) (442, pl. 24, f. 4)
471. *frenchiensis* Gatliff and Gabriel 1908 (*Rissoa*) (444, pl. 24, f. 2)
472. *erma* Cotton 1944 (445, pl. 24, f. 5)
473. *iravadoides* Gatliff and Gabriel 1913 (*Rissoa*) (446, pl. 24, f. 14)
474. *janjucensis* Gatliff and Gabriel 1913 (*Rissoa*) (447, pl. 24, f. 15)
475. *kershawi* Tenison Woods 1877 (*Rissoina*) (448, pl. 24, f. 11)
476. *labrotoma* May 1919 (449, pl. 24, f. 13)
477. *microcosta* May 1919 (450, pl. 24, f. 12)
478. *obeliscus* May 1915 (*Rissoa*) (451, pl. 24, f. 19)
479. *diemenensis* Petterd 1884 (*Rissoa*) (452, pl. 24, f. 10)
480. *perpolita* May 1919 (453, pl. 24, f. 17)
481. *pertumida* May 1915 (*Amphithalamus*) (454, pl. 24, f. 16)
482. *puer* May 1921 (455, pl. 24, f. 20)
483. *rubicunda* Tate and May 1900 (*Rissoa*) (456, pl. 24, f. 7)
484. *tasmanica* Tenison Woods 1876 (*Eulima*) (457, pl. 24, f. 3)
485. *tiara* May 1915 (*Amphithalamus*) (458, pl. 24, f. 18)
486. *tumida* Tenison Woods 1876 (*Diala*) (459, pl. 24, f. 9)

Subestea Cotton 1944 (*seminodosa* May)
487. *seminodosa* May 1915 (*Alvania*) (432, pl. 23, f. 24)
488. *flindersi* Tenison Woods 1876 (*Rissoina*) (443, pl. 24, f. 8)

Haurakia Iredale 1915 (*hamiltoni* Suter)
489. *descrepans* Tate and May 1900 (*Rissoa*) (411, pl. 23, f. 2)
490. *novarensis* Frauenfeld 1867 (*Alvania*) (412, pl. 23, f. 3)
491. *demessa* Tate and May 1900 (*Rissoa*) (410, pl. 23, f. 1)
492. *supracostata* May 1919 (414, pl. 23, f. 5)
493. *mediolaevis* Cotton 1944
494. *sculptilis* May 1919 (*Alvania*) (431, pl. 23, f. 22)
495. *filocincta* Hedley and Petterd 1906 (*Rissoa*) (428, pl. 23, f. 19)

Lironoba Iredale 1915 (*suteri* Hedley)
496. *agnewi* Tenison Woods 1877 (*Rissoa*) (416, pl. 23, f. 7)
497. *archensis* May 1913 (*Rissoa*) (417, pl. 23, f. 8)
498. *freycineti* May 1913 (*Rissoa*) (418, pl. 23, f. 9)
499. *layardi* Petterd 1884 (*Rissoa*) (419, pl. 23, f. 10)
500. *multilirata* May 1915 (*Rissoa*) (420, pl. 23, f. 11)
501. *schoutanica* May 1913 (*Rissoa*) (421, pl. 23, f. 12)
502. *australis* Tenison Woods 1877 (*Cingulina*) (422, pl. 23, f. 13)
503. *unilirata* Tenison Woods 1878 (*Rissoina*) (423, pl. 23, f. 14)
504. *wilsonensis* Gatliff and Gabriel 1913 (*Rissoa*) (424, pl. 23, f. 15)

Botelloides Strand 1928 (*bassiana* Hedley)
505. *bassianus* Hedley 1911 (*Onoba*) (415, pl. 23, f. 6)

Merelina Iredale 1915 (*cheilostoma* T. Woods)
506. *strangei* Brazier 1894 (*Rissoa*) (413, pl. 23, f. 4)
507. *cheilostoma* Tenison Woods 1877 (*Rissoa*) (427, pl. 23, f. 18)
508. *apicilirata* Tate and May 1900 (*Rissoa*) (426, pl. 23, f. 17)
509. *gracilis* Angas 1877 (*Alvania*) (429, pl. 23, f. 20)
510. *hulliana* Tate 1893 (*Rissoa*) (430, pl. 23, f. 21)

Linemaria Finlay 1924 (*interrupta* Finlay)
511. *suprasculpta* May 1915 (*Alvania*) (433, pl. 23, f. 23)
512. *thouinensis* May 1915 (*Alvania*) (434, pl. 23, f. 25)

Notosetia Iredale 1915 (*neozelanica* Suter)
513. *nitens* Frauenfeld 1867 (*Setia*) (470, pl. 25, f. 1)
514. *pellucida* Tate and May 1900 (*Rissoa*) (471, pl. 25, f. 3)
515. *purpureostoma* May 1919 (472, pl. 25, f. 4)
516. *simillima* May 1915 (*Rissoa*) 473, pl. 25, f. 2)

Dardanula Iredale 1915 (*olivacea* Hutton)
517. *aurantiocincta* May 1915 (*Amphithalamus*) (435, pl. 23, f. 26)
518. *dubitabilis* Tate 1899 (*Rissoa*) (436, pl. 23, f. 27)
519. *erratica* May 1912 (*Amphithalamus*) (437, pl. 23, f. 28)
520. *flammea* Frauenfeld 1867 (*Sabanaea*) (438, pl. 23, f. 29)
521. *melanochroma* Tate 1899 (*Rissoa*) (439, pl. 23, f. 30)

Eusetia Cotton 1944 (*expansa* Powell)
522. *brevis* May 1919 (*Rissopsis*) (482, pl. 25, f. 13)
523. *buliminoides* Tate and May 1900 (*Rissopsis*) (483, pl. 25, f. 14)
524. *columnaria* May 1910 (*Aclis*) (484, pl. 25, f. 16)
525. *consobrina* Tate and May 1900 (*Rissopsis*) (485, pl. 25, f. 15)
526. *maccoyi* Tenison Woods 1877 (*Rissoa*) (486, pl. 25, f. 17)
Epigrus Hedley 1903 (*cylindracea* Tenison Woods)
527. *badius* Petterd 1884 (*Rissoa*) (462, pl. 24, f. 25)
528. *cylindraceous* Tenison Woods 1878 (*Rissoina*) (463, pl. 24, f. 23)
529. *dissimilis* Watson 1886 (*Eulima*) (464, pl. 24, f. 24)
530. *semicinctus* May 1915 (465, pl. 24, f. 26)
Scrobs Watson 1886 (*scrobiculator* Watson)
531. *jacksoni* Brazier 1895 (*Rissoa*) (466, pl. 24, f. 29)
532. *luteofuscus* May 1919 (*Amphithalamus*) (467, pl. 24, f. 30)
533. *petterdi* Brazier 1895 (*Rissoa*) (468, pl. 24, f. 28)
Notoscrobs Powell 1927 (*ornata* Powell)
534. *triangulus* May 1915 (*Amphithalamus*) (469, pl. 24, f. 27)
Anabathron Frauenfeld 1867 (*contabulatum* Frauenfeld)
535. *contabulatum* Frauenfeld 1867 (461, pl. 24, f. 21)
Coenaculum Iredale 1924 (*minutula* Tate and May)
536. *minutulum* Tate and May 1900 (*Scalaria*) (425, pl. 23, f. 16)

Family: **Rissoinidae**

Rissoina d'Orbigny 1840 (*inca* d'Orbigny)
s.g. *Moerchiella* Neville 1880 (*gigantea* Deshayes)
537. *gertrudis* Tenison Woods 1876 (*Rissoina*) (477, pl. 25, f. 9)
538. *variegata* Angas 1867 (*Rissoa*) (480, pl. 25, f. 8)
s.g. *Zebinella* Morch 1876 (*decussata* Montagu)
539. *lintea* Hedley and May 1908 (*Rissoina*) (478, pl. 25, f. 10)
540. *fausta* Hedley and May 1908 (*Rissoina*) (479, pl. 25, f. 11)
541. *elegantula* Angas 1880 (*Rissoina*) (474, pl. 25, f. 6)
s.g. *Schwartziella* Neville 1884 (*bryerea* Montagu)
542. *fasciata* A. Adams 1853 (*Rissoina*) (476, pl. 25, f. 7)
Rissolina Gould 1861 (*elegantissima* d'Orbigny)
543. *angasi* Pease 1872 (*Rissoina*) (481, pl. 25, f. 12)
Cithna A. Adams 1863 (*globosa* Adams)
544. *angulata* Hedley 1907 (492, pl. 25, f. 18)
Heterorissoa Iredale 1912 (*secunda* Iredale)
545. *wilfredi* Gatliff and Gabriel 1911 (*Jeffreysia*)

Family: **Hemistomiidae**

Tatea Tenison Woods 1879 (*huonensis* T. Woods)
546. *huonensis* Tenison Woods 1876 (*Bithinia*) (495, pl. 25, f. 26)

Family: **Assimineidae**

Assiminea Fleming 1828 (*grayana* Fleming)
547. *brazieri* Tenison Woods 1876 (*Rissoa*) (493, pl. 25, f. 24)
548. *tasmanica* Tenison Woods 1876 (494, pl. 25, f. 25)

Family: **Tornidae**

Naricava Hedley 1913 (*angasi* A. Adams)
549. *angasi* A. Adams 1863 (*Adeorbis*) (586, pl. 29, f. 6)
550. *vincentiana* Angas 1880 (*Adeorbis*) (587, pl. 29, f. 7)

Family: **Orbitestellidae**

Orbitestella Iredale 1917 (*bastowi* Gatliff)
551. *iredalei* May 1919 (382, pl. 21, f. 16)
552. *mayi* Tate 1899 (*Cyclostrema*) (383, pl. 21, f. 17)

Super-family: **CERITHIACEA**

Family: **Turritellidae**

Ctenocolpus Iredale 1925 (*australis* Lamarck)
553. *granulifera* Tenison Woods 1876 (*Turritella*) (556, pl. 28, f. 3)
554. *australis* Lamarck 1822 (*Turritella*)

Kimberia Cotton and Woods 1935 (*kimberi* Verco)
555. *microscopica* May 1911 (*Turritella*) (560, pl. 28, f. 7)
Colpospira Donald 1900 (*runcinata* Watson)
556. *runcinata* Watson 1881 (*Turritella*)
557. *accisa* Watson 1881 (*Turritella*) (554, pl. 28, f. 1)
Platycolpus Donald 1900 (*quadrata* Donald)
558. *quadrata* Donald 1900 (562, pl. 28, f. 9)
559. *guillaumei* Iredale 1924 (564, pl. 28, f. 11)
Glyptozaria Iredale 1924 (*opulenta* Hedley)
560. *columnaria* Cotton and Woods 1935
561. *opulenta* Hedley 1907 (*Turritella*) (561, pl. 28, f. 8)
Gazameda Iredale 1924 (*gunnii* Reeve)
562. *iredalei* Finlay 1926 (557, pl. 28, f. 4)
563. *gunnii* Reeve 1849 (*Turritella*) (559, pl. 28, f. 6)
564. *tasmanica* Reeve 1849 (*Turritella*) (565, pl. 28, f. 12)
Stiracolpus Finlay 1926 (*symmetrica* Hutton)
565. *godefroyana* Donald 1900 (*Turritella*) (558, pl. 28, f. 5)
566. *atkinsoni* Tate and May 1900 (*Turritella*) (555, pl. 28, f. 2)
567. *smithiana* Donald 1900 (*Turritella*) (563, pl. 28, f. 10)

Family: **Mathildidae**

Opimilda Iredale 1929 (*decorata* Hedley)
568. *decorata* Hedley 1903 (*Mathilda*) (953, pl. 44, f. 8)

Family: **Siliquariidae**

Siliquaria Bruguiere 1789 (*australis* Quoy and Gaimard)
569. *australis* Quoy and Gaimard 1834 (581, pl. 29, f. 1)
Pyxipoma Morch 1860 (*multistriata* Defrance)
570. *weldii* Tenison Woods 1875 (*Tenogodus*) (582, pl. 29, f. 2)
Stethopoma Morch 1860 (*roseus* Quoy and Gaimard)
571. *nucleocostata* May 1915 (580, pl. 28, f. 27)
Vermicularia Lamarck 1799 (*lumbricalis* Linne)
572. *flava* Verco 1907 (576, pl. 28, f. 23)
573. *hedleyi* Finlay 1926 (577, pl. 28, f. 24)
574. *waitei* Hedley 1903 (*Vermetus*) (579, pl. 28, f. 26)
Magilina Velain 1877 (*serpuliformis* Velain)
575. *caperata* Tate and May 1900 (*Thylocodes*) (583, pl. 29, f. 3)

Family: **Solariidae**

Philippia Gray 1847 (*lutea* Lamarck)
576. *lutea* Lamarck 1822 (*Solarium*) (1007, pl. 46, f. 1)
577. *reevei* Hanley 1862 (*Solarium*) (1008, pl. 46, f. 2)

Family: **Vermetidae**

Serpulorbis Sassi 1827 (*polyphragma* Sassi)
578. *sipho* Lamarck 1818 (*serpula*) (578, pl. 28, f. 25)

Family: **Cerithidae**

Zeacumantus Finlay 1926 (*subcarinata* Sowerby)
579. *diemenensis* Quoy and Gaimard 1835 (*Cerithium*) (529, pl. 26, f. 30)
Eubittium Cotton 1937 (*lawleyanum* Crosse)
580. *lawleyanum* Crosse 1863 (*Bittium*) (527, pl. 26, f. 27)
Cacozeliana Strand 1928 (*lacertinium* Gould)
581. *granarium* Kiener 1842 (*Cerithium*) (525, pl. 26, f. 26)
582. *icarus* Bay le 1880 (*Cerithium*) (526, pl. 26, f. 28)
583. *cylindrica* Watson 1886 (*Bittium*) (524, pl. 26, f. 25)
Ataxocerithium Tate 1894 (*serotinum* A. Adams)
584. *serotinum* Adams 1855 (*Cerithium*) (523, pl. 26, f. 24)
585. *rhodostoma* Angas 1871 (*Cerithium*)
Hypotrochus Cotton 1932 (*monachus* Crosse and Fischer)
586. *monachus* Crosse and Fischer 1864 (*Cerithium*) (522, pl. 26, f. 23)
Velacumantus Iredale 1936 (*australis* Quoy and Gaimard)
587. *australis* Quoy and Gaimard 1834 (*Cerithium*) (528, pl. 26, f. 29)
Pyrazus Montford 1810 (*palustris* Linne)
588. *ebeninus* Bruguiere (*Potamides*) (extinct?) (530, pl. 27. f. 1)

Family: **Cerithiopsidae**

Joculator Hedley 1909 (*ridiculus* Watson)
589. *cessicus* Hedley 1906 (*Cerithiopsis*) (532, pl. 27, f. 3)
Seilarex Iredale 1924 (*attenuatus* Hedley)
590. *attenuata* Hedley 1906 (*Seila*) (541, pl. 27, f. 12)
Zaclys Finlay 1926 (*sarissa* Murdoch)
591. *dannevigi* Hedley 1911 (*Cerithiopsis*) (533, pl. 27, f. 4)
592. *semilaevis* Tenison Woods 1877 (*Bittium*) (535, pl. 27, f. 6)
Notoseila Finlay 1926 (*terebelloides* Hutton)
593. *albosutura* Tenison Woods 1877 (*Cerithiopsis*) (538, pl. 27, f. 9)
594. *crocea* Angas 1871 (*Cerithiopsis*) (539, pl. 27, f. 10)
595. *halligani* Hedley 1905 (*Cerithiopsis*) (540, pl. 27, f. 11)
Specula Finlay 1926 (*styliformis* Suter)
596. *mamilla* May 1919 (*Cerithiopsis*) (534, pl. 27, f. 5)
597. *turbonilloides* Tenison Woods 1879 (*Bittium*) (537, pl. 27, f. 8)
Socienna Finlay 1926 (*apicicostata* May)
598. *apicicostata* May 1919 (*Cerithiopsis*) (531, pl. 27, f. 2)
599. *trisculpta* May 1912 (*Cerithiopsis*) (536. pl. 27, f. 7)

Family: **Triphoridae**

Teretriphora Finlay 1926 (*huttoni* Suter)
600. *angasi* Crosse and Fischer 1865 (*Triphora*) (542, pl. 27, f. 13)
601. *cineria* Hedley 1902 (*Triphora*) (544, pl. 27, f. 15)
602. *gemmegens* Verco 1909 (*Triphora*) (, pl. 27, f. 17)
Notosinister Finlay 1926 (*fascelina* Suter)
603. *granifera* Brazier 1894 (*Triphora*) (547, pl. 27, f. 19)
604. *innotabilis* Hedley 1903 (*Triphora*) (548, pl. 27, f. 20)
605. *mamillata* Verco 1909 (*Triphora*) (550, pl. 27, f. 22)
606. *spina* Verco 1909 (*Triphora*) (552, pl. 27, f. 24)
Cautor Finlay 1926 (*obliqua* May)
607. *maculosa* Hedley 1903 (*Triphora*) (549, pl. 27, f. 21)
608. *obliqua* May 1915 (*Triphora*) (551, pl. 27, f. 23)
Eutriphora Cotton and Godfrey 1931 (*cana* Verco)
609. *cana* Verco 1909 (*Triphora*) (533, pl. 27, f. 14)
610. *epallaxa* Verco 1909 (*Triphora*) (545, pl. 27, f. 16)
Isotriphora Cotton and Godfrey 1931 (*tasmanica* T. Woods)
611. *tasmanica* Tenison Woods 1876 (*Triforis*) (553, pl. 27, f. 25)
612. *fasciata* Tenison Woods 1878 (*Triphora*) (546, pl. 27, f. 18)

Family: **Litiopidae**

Diala A. Adams 1861 (*varia* A. Adams)
613. *lauta* A. Adams 1862 (*Alaba*) (487, pl. 25, f. 20)
614. *monile* A. Adams 1862 (*Alaba*) (488, pl. 25, f. 19)
615. *pagodula* A. Adams 1862 (*Alaba*) (489, pl. 25, f. 21)
616. *pulchra* A. Adams 1862 (*Alaba*) (490, pl. 25, f. 22)
617. *translucida* Hedley 1906 (491, pl. 25, f. 23)
618. *varia* A. Adams 1861

Super-family: **PTENOGLOSSA**

Family: **Scalidae**

Scala Bruguiere 1792 (*scalaris* Linne)
s.g. *laeviscala* Boury 1909 (*subauriculata* Souverbie)
619. *aculeata* Sowerby 1844 (*Scalaris*) (?) (588, pl. 29, f. 8)
s.g. *Acutiscala* Boury 1909 (*philipparum* Sowerby)
620. *minora* Iredale 1936 (594, pl. 29, f. 12)
621. *ampacta* Iredale 1936 (592, pl. 29, f. 11)
s.g. *Granuliscala* Boury 1909 (*granosa* Quoy and Gaimard)
622. *granosa* Quoy and Gaimard 1834 (*Turritella*) (590, pl. 29, f. 10)
s.g. *propescala* Cotton and Godfrey 1931 (*translucida* Gatliff)
623. *translucida* Gatliff 1906 (*scala*) (595, pl. 29, f. 15)
s.g. *Platiscala* Iredale 1936 (*morchi* Angas)
624. *morchi* Angas 1871 (*Scala*) (593, pl. 29, f. 13)
625. *invalida* Verco 1906 (*Scala*) (591, pl. 29, f. 14)
s.g. *Opalia* H. and A. Adams 1853 (*australis* Lamarck)

626. *australis* Lamarck 1822 (*Scalaris*) (589, pl. 29, f. 9)

Family: **Ianthinidae**

Ianthina Bolten 1798 (*nitens* Menke)
627. *capreolata* Montrouzier 1859 (584, pl. 29, f. 4)
628. *violacea* Bolten 1798 (585, pl. 29, f. 5)

Super-family: **AGLOSSA**

Family: **Strombiformidae**

Eulima Risso 1826 (*subulata* Donovan)
629. *auger* Angas 1865 (978, pl. 45 f. 3)
630. *columnaria* May 1915 (979, pl. 45, f. 4)
631. *cunaeformis* May 1915 (980, pl. 45, f. 8)
632. *coxi* Pilsbry 1899 (981, pl. 45, f. 5)
633. *inflata* Tate and May 1900 (982, pl. 45, f. 9)
634. *mayii* Tate 1900 (983, pl. 45, f. 7)
635. *mamilla* May 1915 (984, pl. 45, f. 10)
636. *mucronata* Reeve 1866 (985, pl. 45, f. 6)
637. *munita* Hedley 1903 (986, pl. 45, f. 11)
638. *orthopleura* Tate 1898 (987, pl. 45, f. 12)
639. *schoutanica* May 1915 (988, pl. 45, f. 13)
640. *tenisoni* Tryon 1886 (989, pl. 45, f. 14)
641. *tryoni* Tate and May 1900 (991, pl. 45, f. 15)

Stilapex Iredale 1925 (*lactarius* Iredale)
642. *lactarius* Iredale 1925

Melanella Bowdich 1882 (*dufresnii* Bowdich)
643. *petterdi* Beddome 1882 (*Eulima*) (992, pl. 45, f. 17)

Strombiformis Da Costa 1778 (*glaber* Da Costa)
644. *topaziaca* Hedley 1908 (*Eulima*) (990, pl. 45, f. 16)
645. *joshuana* Gatliff and Gabriel 1910 (*Leiostraca*) (993, pl. 45, f. 18)
646. *kilcundae* Gatliff and Gabriel 1914 (*Leiostraca*) (994, pl. 45, f. 19)
647. *lodderae* Hedley 1906 (995, pl. 45, f. 20)
648. *perexigua* Tate and May 1900 (*Rissoa*) (996, pl. 45, f. 21)

Family: **Styliferidae**

Stylifer Broderip 1832 (*astericola* Broderip)
649. *brazieri* Angas 1877 (?) (999)
650. *lodderae* Petterd 1884 (1000, pl. 45, f. 25)
651. *petterdi* Tate and May 1900 (1001, pl. 45, f. 26)

Family: **Pyramidellidae**

Syrnola A. Adams 1860 (*gracillima* A. Adams)
652. *aurantiaca* Angas 1867 (*Styloptygma*) (954, pl. 44, f. 9)
653. *bifasciata* Tenison Woods 1875 (*Obeliscus*) (955, pl. 44, f. 10)
654. *tincta* Angas 1871 (959, pl. 44, f. 14)

Puposyrnola Cossman 1921 (*acicula* Lamarck)
655. *petterdi* Tate and May 1900 (*Syrnola*) (957, pl. 44, f. 12)
656. *tasmanica* Tenison Woods 1877 (*Styloptygma*) (958, pl. 44, f. 13)
657. *harrisoni* Tate and May 1900 (*Syrnola*) (956, pl. 44, f. 11)

Agatha A. Adams 1860 (*virgo* A. Adams)
658. *simplex* Angas 1871 (*Odostomia*) (967, pl. 44, f. 22)
659. *metcalfei* Pritchard and Gatliff 1900 (*Odostomia*) (964, pl. 44, f. 19)

Odostomia Fleming 1813 (*plicata* Montagu)
660. *occultidens* May 1915 (965, pl. 44, f. 20)
661. *deplexa* Tate and May 1900 (*Odontostomia*) (962, pl. 44, f. 17)
662. *tasmanica* Tenison Woods 1876 (969, pl. 44, f. 24)

Egila Dall and Bartsch 1904 (*lacunata* Carpenter)
663. *mayii* Tate 1898 (*Odostomia*) (963, pl. 44, f. 18)

Linopyrga Laws 1941 (*rugata* Hutton)
664. *portseaensis* Gatliff and Gabriel 1911 (*Turbonilla*) (966, pl. 44, f. 21)
665. *crassicosta* May 1915 (*Odostomia*) (961, pl. 44, f. 16)

Miralda A. Adams 1864 (*diadema* A. Adams)
666. *suprasculpta* Tenison Woods 1878 (*Rissoina*) (968, pl. 44, f. 23)

Cinctiuga Laseron 1951 (*diaphana* Verco)
667. *diaphana* Verco 1906 (*Cingulina*) (949, pl. 44, f. 4)

Oscilla A. Adams 1861 (*angulata* A. Adams)
668. *tasmanica* Tenison Woods 1877 (*Parthenia*) (960, pl. 44, f. 15)
Turbonilla Risso 1886 (*lactea* Linne)
669. *beddomei* Petterd 1884 (*Chemnitzia*) (971, pl. 44, f. 26?)
670. *scalpidens* Watson 1886 (*Turbonilla*) (975, pl. 44, f. 30)
Chemnitzia D'Orbigny (*campanellae* Philippi)
671. *hofmani* Angas 1877 (*Turbonilla*) (973, pl. 44, f. 28)
672. *mariae* Tenison Woods 1876 (*Turbonilla*) (974, pl. 44, f. 29)
673. *acicularis* A. Adams 1877 (*Turbonilla*) (970, pl. 44, f. 25)
Pyrgiscus Philippi 1841 (*rufa* Philippi)
674. *fusca* A. Adams 1853 (*Chemnitzia*) (972, pl. 44, f. 27)
675. *varicifera* Tate 1898 (*Turbonilla*) (977, pl. 45, f. 2)
Pyrgiscilla Laws 1937 (*chattonensis* Marwick)
676. *tiara* May 1911 (*Turbonilla*) (976, pl. 45, f. 1)
Eulimella Jeffreys 1847 (*scillae* Gray)
677. *anabathron* Hedley 1906 (1002, pl. 45, f. 27)
678. *coacta* Watson 1886 (1003, pl. 45, f. 29)
679. *micra* Petterd 1884 (*Aclis*) (1004, pl. 45, f. 30)
680. *moniliformis* Hedley and Musson 1891 (1005, pl. 45, f. 28)
681. *turrita* Petterd 1884 (*Aclis*) (1006, pl. 45, f. 31)
Cingulina A. Adams 1860 (*circinata* A. Adams)
682. *insignis* May 1911 (950, pl. 44, f. 5)
683. *magna* Gatliff and Gabriel 1911 (951, pl. 44, f. 6)
684. *spina* Crosse and Fischer 1864 (*Turritella*) (952, pl. 44, f. 7)
Leucotina A. Adams 1860 (*niphonensis* A. Adams)
685. *concinna* Adams 1854 (*Monoptygma*) (47, pl. 44, f. 2)
686. *micra* Pritchard and Gatliff 1900 (*Turbonilla*) (948, pl. 44, f. 3)
Pseudorissoina Tate and May 1900 (*tasmanica* T. Woods)
687. *tasmanica* Tenison Woods 1877 (*Stylifer*) (998, pl. 45, f. 23)
688. *capiticava* Hedley and May 1908 (997, pl. 45, f. 22)

Super-family: **HIPPONICACEA**

Family: **Hipponicidae**

Sabia Reeve 1842 (*conica* Schumacher)
689. *conica* Schumacher 1817 (*Amalthea*) (514, pl. 26, f. 15)
Antisabia Iredale 1937 (*foliacea* Quoy and Gaimard)
690. *foliacea* Quoy and Gaimard 1835 (*Hipponix*) (515, pl. 26, f. 16)

Super-family: **CHEILEACEA**

Family: **Capulidae**

Capulus Montfort 1810 (*hungaricus* Linne)
691. *devotus* Hedley 1904 (520, pl. 26, f. 20)
692. *devexus* May 1915 (*Roya*) (519, pl. 26, f. 21)
693. *violaceus* Angas 1867 (521, pl 26. f. 22)

Family: **Lippistidae**

Icuncula Iredale 1924 (*torcularis* Tenison Woods)
694. *torcularis* Tenison Woods 1878 (*Cingulina*) (573, pl. 28, f. 21)
695. *consobrina* May 1919 (*Lippistes*) (571, pl. 28, f. 18)
696. *zodiacus* Hedley 1907 (*Lippistes*) (574, pl. 28, f. 19)
Zelippistes Finlay 1926 (*benhami* Suter)
697. *meridionalis* Verco 1906 (*Lippistes*) (572, pl. 28, f. 20)

Family: **Siriidae**

Sirius Hedley 1900 (*badius* Tenison Woods)
698. *badius* Tenison Woods 1878 (*Raulinia*) (575, pl. 28, f. 22)
698a. (*meracus*) *chestus* Iredale 1936

Family: **Galeridae**

Sigapatella Lesson 1834 (*novaezelandiae* Benson)
699. *calyptraeformis* Lamarck 1822 (*Trochus*) (516, pl. 26, f. 17)
Zegalerus Finlay 1926 (*tenuis* Gray)
700. *hedleyi* Smith 1915 (*Sigapatella*) (517, pl. 26, f. 18)
Zeacrypta Finlay 1926 (*monoxyla* Lesson)
701. *immersa* Angas 1865 (*Crepedula*) (518, pl. 26, f. 19)

Super-family: **NATICACEA**

Family: **Naticidae**

Notocochlis Powell 1933 (*migratoria* Powell)
702. *elkingtoni* Hedley and May 1908 (*Natica*) (611, pl. 30, f. 3)
703. *euzona* Recluz 1843 (*Natica*) (612, pl. 30, f. 4)
704. *schoutanica* May 1912 (*Natica*) (613, pl. 30, f. 5)
705. *sticta* Verco 1909 (*Natica*) (615, pl. 30, f. 7)
706. *kingensis* May 1924 (*Natica*)
Uber Humphrey 1797 (*mammila* Linne)
707. *aulacoglossa* Pilsbry and Vanatta 1908 (*Polinices*) (617, pl. 30, f. 9)
708. *catenoides* May 1919 (*Polinices*) (618, pl. 30, f. 10)
709. *conicum* Lamarck 1822 (*Natica*) (619, pl. 30, f. 11)
710. *tasmanicum* Tenison Woods 1876 (*Natica*) (620, pl. 30, f. 12)
711. *controversum* Pritchard and Gatliff 1913
Cochlis Bolten 1798 (*albula* Bolten)
712. *shorehami* Pritchard and Gatliff 1900 (*Natica*) (614, pl. 30, f. 6)
Quantonatica Iredale 1936 (*subcostata* Tenison Woods)
713. *subcostata* Tenison Woods 1877 (*Natica*) (616, pl. 30, f. 8)
Friginatica Hedley 1916 (*beddomei* Johnston)
714. *beddomei* Johnston 1884 (*Natica*) (621, pl. 30, f. 13)
Ectosinum Iredale 1931 (*pauloconvexum* Iredale)
715. *zonale* Quoy and Gaimard 1832 (*Cryptosoma*) (623, pl. 30, f. 15)
Propesinum Iredale 1924 (*umbilicatus* Quoy and Gaimard)
716. *umbilicatum* Quoy and Gaimard 1833 (*Natica*) (622, pl. 30, f. 14)

Super-family: **LAMELLARIACEA**

Family: **Lamellariidae**

Lamellaria Montagu 1815 (*perspicua* Linne)
717. *ophione* Gray 1850 (626, pl. 30, f. 21)

Super-family: **CYPRAEACEA**

Family: **Cypraeidae**

Sub-family: *Cypraeovulinae*

Notocypraea Schilder 1927 (*piperata* Gray)
718. *piperita* Gray 1825 (*Cypraea*)
719. *bicolor* Gaskoin 1849 (*Cypraea*)
720. *verconis* Cotton and Godfrey 1932 (627, pl. 30, f. 19)
721. *albata* Beddome 1898 (*Cypraea*) (pl. 30, f. 20)
722. *declivis* Sowerby 1870 (*Cypraea*)
Umbilia Jousseaume 1884 (*umbilicata* Sowerby)
723. *hesitata* Iredale 1916 = *umbilicata* Sowerby 1825 (*Cypraea*) (628, pl. 30, f. 18)

Family: **Eratoidae**

Lachryma Sowerby 1832 (*lachryma* Sowerby)
724. *bimaculata* Tate 1878 (*Erato*) (630, pl. 30, f. 23)
725. *denticulata* Pritchard and Gatliff 1900 (*Erato*) (631, pl. 30, f. 22)

Family: **Triviidae**

Ellatrivia Iredale 1931 (*merces* Iredale)
726. *merces* Iredale 1924 (*Triviella*) (629, pl. 30, f. 24)

Super-family: **DOLIACEA**

Family: **Cassididae**

Xenogalea Iredale 1927 (*pyrum* Lamarck)
727. *pyrum* Lamarck 1822 (*Cassis*) (609, pl. 30, f. 1)
728. *stadialis* Hedley 1914 (*Cassidea*)
729. *nivea* Brazier 1872 (*Cassis*)
730. *denda* Cotton 1945 (?))
Antephalium Iredale 1927 (*semigranosum* Lamarck)
731. *semigranosum* Lamarck 1822 (*Cassis*) (610, pl. 30, f. 2)

Family: Cymatiidae

Charonia Gistel 1848 (*tritonis* Linne)
732. *rubicunda* Perry 1811 (*Septa*) (596, pl. 29, f. 18)
Cymatilesta Iredale 1936 (*spengleri* Perry)
733. *barthelemyi* Bernardi 1857 (*Triton*) (598, pl. 29, f. 19)
734. *waterhousei* Adams and Angas 1864 (*Triton*) (599, pl. 29, f. 20)
Cymatona Iredale 1929 (*kampyla* Watson)
735. *kampyla* Watson 1886 (*Nassarius*) (600, pl. 29, f. 17)
Gondwanula Finlay 1926 (*tumida* Dunker)
736. *bassi* Angas 1869 (*Triton*) (607, pl. 29, f. 28)
737. *tumida* Dunker 1864 (*Ranella*) (608, pl. 29, f. 22)
Negyrina Iredale 1929 (*subdistorta* Lamarck)
738. *subdistorta* Lamarck 1822 (*Triton*) (602, pl. 29, f. 23)
739. *petulans* Hedley and May 1908 (*Septa*) 601, pl. 29, f. 24)
Mayena Iredale 1917 (*australasia* Perry)
740. *australasia* Perry 1811 (*Biplex*) (603, pl. 29, f. 21)
Cymatiella Iredale 1924 (*quoyi* Reeve)
741. *columnaria* Hedley and May 1908 (*Cymatium*) (604, pl. 29, f. 25)
742. *lesueuri* Iredale 1929 (605, pl. 29, f. 26)
743. *verrucosa* Reeve 1844 (*Triton*) (606, pl. 29, f. 27)
Austrosassia Finlay 1931 (*parkinsoniana* Perry)
744. *parkinsoniana* Perry 1811 (*Septa*) (597, pl. 29, f. 16)
Ratifusus Iredale 1929 (*adjunctus* Iredale)
745. *mestayerae* Iredale 1915 (798, pl. 38, f. 8)
746. *bednalli* Brazier 1875 (*Triton*) (799, pl. 38, f. 7)
747. *schoutanicus* May 1910 (*Pisania*) (800, pl. 38, f. 9)

Sub-order: Stenoglossa

Section: *Rachiglossa*

Super-family: MURICACEA

Family: Muricidae

Murexsul Iredale 1915 (*octonus* Quoy and Gaimard)
748. *brazieri* Angas 1863 (*Murex*) (837, pl. 39, f. 20)
749. *umbilicatus* Tenison Woods 1876 (*Trophon*) (839, pl. 39, f. 22)
Pterynotus Swainson 1833 (*pinnatus* Swainson)
750. *angasi* Crosse 1863 (*Typhis*) (836, pl. 39, f. 19)
751. *triformis* Reeve 1845 (*Murex*) (838, pl. 39, f. 21)
Galfridus Iredale 1924 (*speciosus* Angas)
752. *eburneus* Petterd 1884 (*Trophon*) (853, pl. 40, f. 11)
Cyphonochelus Jouseame 1882 (*arcuatus* Hinds)
753. *syringianus* Hedley 1903 (*Typhis*) (854, pl. 40, f. 13)
Litozamia Iredale 1929 (*rudolphi* Brazier)
754. *brazieri* Tenison Woods 1876 (*Trophon*) (840, pl. 39, f. 23)
755. *goldsteini* Tenison Woods 1876 (*Trophon*) (843, pl. 40, f. 1)
756. *rudolphi* Brazier 1894 (*Peristernia*) (849, pl. 40, f. 7)
Benthoxystus Iredale 1929 (*columnarius* Hedley and May)
757. *columnarius* Hedley and May 1908 (*Trophon*) (841, pl. 39, f. 24)
758. *petterdi* Crosse 1870 (*Trophon*) (847, pl. 40, f. 5)
759. *recurvatus* Verco 1909 (*Trophon*) (848, pl. 40, f. 6)
Apixystus Iredale 1929 (*stimuleus* Hedley)
760. *segmentatus* Verco 1909 (*Trophon*) (851, pl. 40, f. 9)
Gemixystus Iredale 1929 (*laminatus* Petterd)
761. *laminatus* Petterd 1884 (*Trophon*) (844, pl. 40, f. 2)
Anatrophon Iredale 1929 (*sarmentosus* Hedley and May)
762. *sarmentosus* Hedley and May 1908 (*Trophon*) (850, pl. 40, f. 8)
Enatimene Iredale 1929 (*simplex* Hedley)
763. *simplex* Hedley 1903 (*Trophon*) (852, pl. 40, f. 10)
Emozamia Iredale 1929 (*licinus* Hedley and Petterd)
764. *licinus* Hedley and Petterd 1906 (*Murex*) (845, pl. 40, f. 3)
Bedeva Iredale 1924 (*hanleyi* Angas)
765. *assisi* Tenison Woods 1877 (*Trophon*) (855, pl. 40, f. 12)

Family: Thaididae

Dicathais Iredale 1936 (*orbita* Gmelin)
766. *baileyana* Tenison Woods 1881 (*Purpura*) (856, pl. 40, f. 14)
767. *textiliosa* Lamarck 1822 (*Purpura*) (857, pl. 40, f. 15)
Lepsiella Iredale 1912 (*scobina* Quoy and Gaimard)
768. *vinosa* Lamarck 1822 (*Buccinum*) (861, pl. 40, f. 18)
769. var. *aurea* Crosse and Fischer 1865
770. *reticulata* Blainville 1832 (Purpura) (860, pl. 40, f. 19)
771. *adelaidae* Adams and Angus 1863 (*Adamsia*) (859, pl. 40, f. 17)
Tolema Iredale 1929 (*sertata* Hedley)
772. *sertata* Hedley 1902 (*Purpura*) (862, pl. 40, f. 20)
Agnewia Tenison Woods (*typica* Dunker)
773. *tritoniformis* Blainville 1832 (*Purpura*) (858, pl. 40, f. 16)

Super-family: BUCCINACEA

Family: Pyrenidae

Zemitrella Finlay 1926 (*sulcata* Hutton)
774. *menkeana* Reeve 1858 (*Columbella*) (810, pl. 38, f. 19)
775. *austrina* Gaskoin 1851 (*Columbella*) (811, pl. 38, f. 20)
776. *axiaerata* Verco 1910 (*Pyrene*) (812, pl. 38, f. 21)
777. *vincta* Tate 1893 (*Columbella*) (815, pl. 38, f. 24)
778. *lincolnensis* Reeve 1859 (*Columbella*) (816, pl. 38, f. 25)
779. *pulla* Gaskoin 1851 (*Columbella*) (817, pl. 39, f. 1)
780. *dictua* Tenison Woods 1878 (*Columbella*)
781. *semiconvexa* Lamarck 1822 (*Buccinum*) (818, pl. 39, f. 2)
782. *tayloriana* Reeve 1859 (*Columbella*) (819, pl. 39, f. 3)
Zella Iredale 1924 (*beddomei* Petterd)
783. *beddomei* Petterd 1884 (*Terebra*) (813, pl. 38, f. 22)
Paxula Finlay 1926 (*paxulus* Murdoch)
784. *jaffaensis* Verco 1910 (*Pyrene*) (814, pl. 38, f. 23)
Macrozafra Finlay 1926 (*subabnormis* Suter)
785. *atkinsoni* Tenison Woods 1876 (*Magelia*) (827, pl. 39, f. 10)
786. *beachportensis* Verco 1910 (*Pyrene*) (828), pl. 39, f. 11)
787. *columnaria* May 1915 (*Zafra*) (829, pl. 39, f. 12)
788. *fulgida* Reeve 1859 (*Columbella*) (830, pl. 39, f. 13)
789. *legrandi* Tenison Woods 1876 (*Columbella*) (831, pl. 39, f. 14)
790. *lurida* Hedley 1907 (*Pyrene*) (832, pl. 39, f. 15)
791. *calva* Verco 1910 (*Pyrene*) (833, pl. 39, f. 16)
Pseudamycla Pace 1902 (*dermestoidea* Lamarck)
792. *dermestoidea* Lamarck 1822 (*Buccinum*) (820, pl. 39, f. 4)
793. *miltostoma* Tenison Woods 1876 (*Columbella*) (821, pl. 39, f. 5)
Antizafra Finlay 1926 (*pisaniopsis* Hutton)
794. *plexa* Hedley 1901 (*Columbella*) (835, pl. 39, f. 18)
Retizafra Hedley 1918 (*gemmulifera* Hedley)
795. *multicostata* May 1910 (*Mitramorpha*) (834, pl. 39, f. 17)
Aesopus Gould 1860 (*japonicus* Gould)
796. *cassandra* Hedley 1909 (*Daphnella*) (822, pl. 39, f. 6)
797. *pallidulus* Hedley 1907 (*Mitramorpha*) (824, pl. 39, f. 7)
798. *plurisulcatus* Reeve 1859 (*Columbella*) (825, pl. 39, f. 8)
798a. *solidus* May 1911 (*Mitromorpha*) (826, pl. 39, f. 9)

Family: Buccinidae

Cominella Gray 1850 (*testudinea* Martyn)
799. *eburnea* Reeve 1846 (*Buccinum*) (792, pl. 38, f. 1)
800. *kingicola* Tate and May 1900 (*Cantharus*) (793, pl. 38, f. 2)
801. *lineolata* Lamarck 1809 (*Buccinum*) (794, pl. 38, f. 3)
Tasmeuthria Iredale 1925 (*clarkei* Tenison Woods)
802. *clarkei* Tenison Woods 1876 (*Siphonalia*) (796, pl. 38, f. 5)
Josepha Tenison Woods 1879 (*tasmanica* Tenison Woods)
803. *tasmanica* Tenison Woods 1879 (795, pl. 38, f. 4)
Fax. Iredale 1925 (*tabidus* Hedley)
804. *tenuicostata* Tenison Woods 1877 (*Cominella*) (797, pl. 38, f. 6)
805. *conspicienda* Iredale 1925)

Family: **Austrosiphonidae**

Austrosipho Cossman 1906 (*roblini* Tate)
s.g. *Berylsma* Iredale 1924 (*waitei* Hedley)
806. *grandis* Gray 1839 (*fusus*) (774, pl. 37, f. 7)
807. *maxima* Tryon 1881 (*Siphonalia*) (772, pl. 37, f. 5)

Family: **Nassariidae**

Parcanassa Iredale 1936 (*ellana* Iredale)
808. *burchardi* Philippi 1851 (*Buccinum*) (803, pl. 38, f. 12)
809. *pauperata* Lamarck 1822 (*Buccinum*) (806, pl. 38, f. 15)
Tavaniotha Iredale 1936 (*optata* Gould)
810. *munieriana* Crosse 1864 (*Nassa*) (807, pl. 38, f. 16)
811. *tasmanicus* Tenison Woods 1875 (*Nassa*) (813, pl. 38, f. 17)
Reticunassa Iredale 1936 (*paupera* Gould)
812. *paupera* Gould 1850 (*Nassa*) (805, pl. 38, f. 14)
813. *mobilis* Hedley and May 1908 (*Arcularia*) (804, pl. 38, f. 13)
Niotha H. and A. Adams 1853 (*cumingi* A. Adams)
814. (*pyrrhus*) victorianus Iredale 1915 (*Alectrion*) (809, pl. 38, f. 18)

Family: **Fasciolariidae**

Pleuroploca Fischer 1884 (*trapezium* Linne)
815. *australasia* Perry 1811 (*Pyrula*) (768)
816. *coronata* Lamarck 1822 (*Fasciolaria*) (pl. 37, f. 1)
817. *fusiformis* Valenciennes 1840 (*Fasciolaria*) (769, pl. 37, f. 2)
Fractolatirus Iredale 1936 (*normalis* Iredale)
818. *spiceri* Tenison Woods 1876 (*Fusus*) (770, pl. 37, f. 3)

Family: **Colidae**

Colus Humphrey 1797 (*colus* Linne)
819. *novaehollandiae* Reeve 1848 (*Fusus*) (776, pl. 37, f. 10)
Propefusus Iredale 1924 (*pyrulatus* Reeve)
820. *pyrulatus* Reeve 1847 (*Fusus*) (773, pl. 37, f. 8)
821. *undulatus* Perry 1871 (*Pyrula*) (775, pl. 37, f. 9)
Microcolus Cotton and Godfrey 1932 (*dunkeri* Jonas)
822. *dunkeri* Jonas 1844 (*Fusus*) (771, pl. 37, f. 4)

Super-family: **VOLUTACEA**

Family: **Zemiridae**

Zemira H. and A. Adams (*australis* Sowerby)
823. *australis* Sowerby 1841 (*Eburna*) (802, pl. 38, f. 11)

Family: **Olividae**

Cupidoliva Iredale 1924 (*nympha* Adams and Angas)
824. *nympha* A. Adams and Angas 1863 (*Olivella*) (639, pl. 33, f. 8)
Belloliva Peile 1922 (*brazieri* Angas)
825. *leucozona* A. Adams and Angas 1863 (*Olivella*) (638, pl. 33, f. 7)
s.g. *Gemmoliva* Iredale 1924 (*pardalis* A. Adams and Angas)
826. *pardalis* A. Adams and Angas 1863 (*Oliva*) (640, pl. 33, f. 9)
Baryspira Fischer 1883 (*australis* Sowerby)
827. *marginata* Lamarck 1810 (*Ancillaria*) (641, pl. 33, f. 11)
828. *oblonga* Sowerby 1880 (*Ancillaria*) (642, pl. 33, f. 10)
829. *fusiformis* Petterd 1886 (*Ancillaria*)
830. *petterdi* Tate 1893 (*Ancillaria*) (643, pl. 33, f. 12)
831. *tasmanica* Tenison Woods 1876 (*Ancillaria*)
832. *edithae* Pritchard and Gatliff 1898 (*Ancillaria*)

Family: **Mitridae**

Mitra Bolten 1798 (*episcopalis* Linne)
833. *australis* Swainson 1822 (777, pl. 37, f. 11)
834. *glabra* Swainson 1821 (780, pl. 37, f. 6)
835. *rhodia* Reeve 1845 (785, pl. 37, f. 13)
835a. *strangei* Angas 1867 (787, pl. 37, f. 14)

Austromitra Finlay 1926 (*rubiginosa* Hutton)
836. *cinnamonea* A. Adams 1854 (*Volutomitra*) (779)
837. *legrandi* Tenison Woods 1876 (*Mitra*) (781, pl. 37, f. 18)
838. *pumilio* May 1915 (*Vexillum*) (783, pl. 37, f. 19)
839. *retrocurvata* Verco 1909 (*Mitra*) (784, pl. 37, f. 17)
840. *bellapicta* Verco 1909 (*Mitra*)? (778, pl. 37, f. 21)
841. *scalariformis* Tenison Woods 1876 (*Mitra*) (786, pl. 37, f. 20)
842. *tasmanica* Tenison Woods 1876 (*Mitra*) (788, pl. 37, f. 15)
843. *analogica* Reeve 1845 (*Mitra*) (789, pl. 37, f. 16)
Proximitra Finlay 1926 (*rutidolomum* Suter)
844. *pica* Reeve 1845 (*Mitra*) (782, pl. 37, f. 12)
Peculata Iredale 1924 (*verconis* Iredale)
845. *porphyria* Verco 1896 (*Imbricaria*) (791, pl. 37, f. 23)
Microvoluta Angas 1877 (*australis* Angas)
846. *purpureostoma* Hedley and May 1908 (790, pl. 37, f. 22)

Family: **Volutidae**

Amorena Iredale 1929 (*undulata* Lamarck)
847. *undulata* Lamarck 1804 (*Voluta*) (632, pl. 33, f. 1)
848. *kingi* Cox 1871 (*Voluta*)
849. *slateri* Cox 1869 (*Voluta*)
Ericusa H. and A. Adams 1858 (*papillosa* Swainson)
850. *papillosa* Swainson 1820 (*Voluta*) (633, pl. 33, f. 3)
Mesericusa Iredale 1929 (*perspicta* Iredale)
851. *sowerbyi* Kiener 1839 (*Voluta*) (634, pl. 33, f. 2)
Pterospira Harris 1897 (*hannafordi* McCoy)
852. *roadknightae* McCoy 1881 (*Voluta*) (636, pl. 33, f. 5)
Mamillana Crosse 1871 (*mamilla* Gray)
853. *mamilla* Gray 1844 (*Voluta*) (635, pl. 33, f. 4)
Lyria Gray 1847, (*nucleus* Lamarck)
854. *mitraeformis* Lamarck 1804 (*Voluta*) (637, pl. 33, f. 6)

Family: **Cancellariidae**

Sydaphera Iredale 1929 (*renovata* Iredale)
855. *undulata* Sowerby 1848 (*Cancellaria*) (697, pl. 34, f. 1)
856. *granosa* Sowerby 1841 (*Cancellaria*) (698, pl. 34, f. 2)
857. *lactea* Deshayes 1856 (*Cancellaria*) (699, pl. 34, f. 3)
858. *purpuraeformis* Kuster 1841 (*Cancellaria*) (701, pl. 34, f. 4)
Nevia Jousseaume 1887 (*excavata* Sowerby = *spirata* Lamarck)
859. *spirata* Lamarck 1822 (*Cancellaria*) (702, pl. 34, f. 5)
Pepta Iredale 1925 (*stricta* Hedley)
860. *stricta* Hedley 1907 (*Admete*) (703, pl. 34, f. 7)
Oamaruia Finlay 1924 (*suteri* Marshall and Murdoch)
861. *pergradata* Verco 1905 (*Cancellaria*) (700, pl. 34, f. 6)

Family: **Marginellidae**

Marginella Lamarck 1799 (*glabella* Linne)
Group A.
862. *muscaria* Lamarck 1822 (681, pl. 31, f. 1)
863. *johnstoni* Petterd 1884 (673, pl. 31, f. 2)
864. *tasmanica* Tenison Woods 1875 (691, pl. 31, f. 6)
865. *mixta* Petterd 1884 (694, pl. 31, f. 7)
866. *pygmaeoides* Singleton 1937 (686, pl. 31, f. 9)
867. *schoutanica* May 1913 (688, pl. 31, f. 10)
868. *consobrina* May 1911 (654, pl. 31, f. 20)
869. *vercoi* May 1911 (665, pl. 31, f. 21)
870. *inconspicua* Sowerby 1846 (670, pl. 31, f. 25)
Group B.
871. *formicula* Lamarck 1822 (662, pl. 31, f. 3)
872. *georgiana* May 1915 (666, pl. 31, f. 4)
873. *praetermissa* May 1916 (685, pl. 31, f. 5)
874. *turbinata* Sowerby 1846 (695, pl. 31, f. 8)
Group C.
875. *maugeana* Hedley 1915 (677, pl. 31, f. 14)
876. *gabrieli* May 1911 (663, pl. 31, f. 24)

877. *caducocincta* May 1916 (650, pl. 311, f. 11)
878. *lodderae* May 1910 (675, pl. 31, f. 15)
879. *dentiens* May 1911 (653, pl. 31, f. 17)
880. *kemblensis* Hedley 1903 (674, pl. 31, f. 16)
881. *allporti* Tenison Woods 1876 (645, pl. 31, f. 12)
882. *mayi* Tate 1900 (678, pl. 31, f. 13)

Group D.

883. *connectans* May 1911 (653, pl. 32, f. 2)
884. *freycineti* May 1916 (681, pl. 32, f. 3)
885. *incerta* May 1920 (669, pl. 32, f. 4)
886. *agapeta* Watson 1886 (644,
887. *altilabra* May 1911 (647, pl. 32, f. 6)
888. *diplostreptus* May 1916 (659, pl. 32, f. 8)
889. *beddomei* Petterd 1884 (689, pl. 32, f. 9)
890. *subauriculata* May 1916 (690, pl. 32, f. 10)
891. *lubrica* Petterd 1884 (676, pl. 32, f. 12)
892. *angasi* Crosse 1870 (648, pl. 32, f. 13)
893. *simsoni* Tate and May 1900 (, pl. 32, f. 14)
894. *ringens* May 1919 (687, pl. 32, f. 15)
895. *obesula* May 1919 (683, pl. 32, f. 17)
896. *procella* May 1916 (672, pl. 32, f. 1)
897. *baca* Cotton 1949 (, pl. 32, f. 5)

Group E.

898. *tomliniana* May 1917 (693, pl. 32, f. 11)
899. *indescreta* May 1911 (671, pl. 32, f. 16)
900. *cratericula* Tate and May 1900 (655, pl. 32, f. 16)
901. *concamerata* May 1918 (652, pl. 32, f. 19)
902. *petterdi* Beddome 1883 (684, pl. 32, f. 20)
903. *minutissima* Tenison Woods 1876 (679, pl. 32, f. 21)
904. *thouinensis* May 1916 (692, pl. 32, f. 22)
905. *multidentata* May 1920 (680, pl. 32, f. 23)
906. *inaequidens* May 1913 (668, pl. 32, f. 25)
907. *bucca* Tomlin 1916 (649, pl. 32, f. 26)
908. *cymbalum* Tate 1878 (657, pl. 32, f. 27)
909. *cylichnella* May 1918 (656, pl. 32, f. 29)
910. *erma* Cotton 1944 (, pl. 32, f. 30)
911. *multiplicata* Tate and May 1900 (646, pl. 32, f. 24)
912. *flindersi* Pritchard and Gatliff 1899 (660, pl. 32, f. 28)

Group F.

913. *mustellina* Angas 1871 (682, pl. 31, f. 18)
914. *vincentiana* Cotton 1944
915. *hedleyi* May 1911 (667, pl. 31, f. 19)
916. *columnaria* Hedley and May 1908 (651, pl. 32, f. 7)

Group G.

917. *geminata* Hedley 1912 (665, pl. 31, f. 22)
918. *gatliffi* May 1911 (664, pl. 31, f. 23)

Super-family: **TOXOGLOSSA**

Family: **Turridae**

Sub-family: *Turrinae*

Epidirona Iredale 1931 (*hedleyi* Iredale)

919. *quoyi* Desmoulins 1833 (*Pleurotoma*) (713, pl. 34, f. 17)
920. *philipineri* Tenison Woods 1877 (*Pleurotoma*)
921. *torquata* Hedley 1922 (*Epideira*)

Epiderella Iredale 1922 (*tasmanica* May)

922. *tasmanica* May 1911 (*Hemipleurotoma*) (714, pl. 34, f. 18)

Epideira Hedley 1922 (*striata* Gray)

923. *schoutanica* May 1911 (*Drillia*) (743, pl. 35, f. 23)

Sub-family: *Clavinae*

Inquisitor Hedley 1918 (*sterrha* Watson)

924. *coxi* Angas 1867 (*Drillia*) (740, pl. 35, f. 20)
925. *immaculatus* Tenison Woods 1876 (*Mangelia*) (741, pl. 35, f. 21)

Austrodrillia Hedley 1918 (*angasi* Crosse)
926. *beraudiana* Crosse 1863 (*Pleurotoma*) (735, pl. 35, f. 15)
927. *nenia* Hedley 1903 (*Drillia*) (736, pl. 35, f. 16)
928. *saxea* Sowerby 1896 (*Drillia*) (737, pl. 35, f. 17)
Splendrilla Hedley 1922 (*woodsi* Beddome)
929. *woodsi* Beddome 1883 (*Drillia*) (739, pl. 35, f. 19)
Antemelatoma Powell 1942 (*maorum* Smith)
930. *subviridis* May 1911 (*Drillia*) (738, pl. 35, f. 18)

Sub-family: *Borsoniinae*

Mitrathara Hedley 1922 (*alba* Petterd)
931. *alba* Petterd 1879 (*Columbella*) (717, pl. 34, f. 21)
932. *angusta* Verco 1909 (*Mitromorpha*) (718, pl. 34, f. 22)
933. *costifera* May 1919 (*Apaturris*) (719, pl. 34, f. 23)
934. *columnaria* Hedley 1922
935. *multicostata* May 1911 (*Drillia*)

Sub-family: *Mangeliinae*

Guraleus Hedley 1918 (*picta* Adams and Angas)
936. *pictus* Adams and Angas 1864 (*Mangilia*) (728, pl. 35, f. 7)
937. *alucinans* Sowerby 1896 (*Mangilia*) (pl. 35, f. 8)
938. *incrustus* Tenison Woods 1877 (*Drillia*) (725, pl. 35, f. 4)
939. *varix* Tenison Woods 1877 (*Daphnella*) (, pl. 35, f. 25)
940. *cuspis* Sowerby 1896 (*Mangelia*) (721, pl. 34, f. 25)
941. *connectans* Sowerby 1896 (*Mangelia*)
942. *granulosissimus* Tenison Woods 1879 (*Clathurella*) (732, pl. 35, f. 12)
943. *delicatulus* Tenison Woods 1879 (*Mangelia*) (722, pl. 35, f. 1)
944. *meridithae* Tenison Woods 1876 (*Mangelia*)
Euguraleus Cotton 1947 (*anisus* Cotton)
945. *tasmanicus* Tenison Woods 1876 (*Cythara*) (730, pl. 35, f. 10)
946. *letourneuxianus* Crosse and Fischer 1865 (*Pleurotoma*)
947. *lallemantianus* Crosse and Fischer 1865 (*Pleurotoma*)
948. *australis* Adams and Angas 1864 (*Bela*)
Marita Hedley 1922 (*compta* Adams and Angas)
949. *bella* Adams and Angas 1864 (*Cithara*) (720, pl. 34, f. 24)
950. *compta* Adams and Angas 1864 (*Cithara*) (745, pl. 35, f. 25)
951. *fallaciosa* Sowerby 1896 (*Daphnella*) (723, pl. 35, f. 3)
952. *flaccida* Pritchard and Gatliff 1899 (*Mangelia*) (724, pl. 35, f. 2)
953. *kingensis* Petterd 1879 (*Daphnella*) (726, pl. 35, f. 5)
954. *mitralis* Adams and Angas 1864 (*Bela*) (727, pl. 35, f. 6)
955. *schoutenensis* May 1901 (*Mangelia*) (729, pl. 35, f. 9)
Heterocithara Hedley 1922 (*bilineata* Angas)
956. *bilineata* Angas 1871 (*Clathurella*) (?) (731, pl. 35, f. 11)
Etrema Hedley 1918 (*aliciae* Melville and Standen)
957. *bicolor* Angas 1871 (*Clathurella*) (748, pl. 36, f. 4)
958. *densiplicata* Dunker 1871 (*Pleurotoma*) (761, pl. 36, f. 19)
959. *kymatoessa* Watson 1886 (*Pleurotoma*)
Filodrillia Hedley 1922 (*tricarinata* T. Woods)
960. *tricarinata* Tenison Woods 1878 (*Drillia*) (744, pl. 35, f. 24)
961. *columnaria* Hedley 1922
962. *dilecta* Hedley 1903 (*Drillia*) (749, pl. 36, f. 5)
963. *dulcis* Sowerby 1896 (*Daphnella*)
964. *hilum* Hedley 1908 (*Mangelia*) (823, pl. 36, f. 25)
965 *lacteola* Verco 1909 (*Drillia*) (742, pl. 35, f. 22)
966. *ornata* Hedley 1922 (, pl. 36, f. 20)
967. *recta* Hedley 1903 (*Leucosyrinx*) (716, pl. 34, f. 20)
Macteola Hedley 1918 (*anomala* Angas)
968. *anomala* Angas 1877 (*Purpura*) (747, pl. 36, f. 3)
Eucithara Fischer 1883 (*stromboides* Reeve)
969. *pagoda* May 1911 (*Daphnella*) (766, pl. 36, f. 26)

Sub-family: *Daphnellinae*

Asperdaphne Hedley 1922 (*versivestitia* Hedley)
970. *bela* Hedley 1922 (767, pl. 36, f. 27)
971. *desalesii* Tenison Woods 1877 (*Mangelia*) (762, pl. 36, f. 21)

972. *esperanza* May 1911 (*Hemipleurotoma*) (715, pl. 34, f. 19)
973. *sculptilis* Angas 1871 (*Clathurella*) (763, pl. 36, f. 22)
974. *tasmanica* Tenison Woods 1877 (*Daphnella*) (759, pl. 36, f. 14)

Aspertilla Powell 1944 (*legrandi* Beddome)
975. *legrandi* Beddome 1883 (*Drillia*) (757, pl. 36, f. 13)

Exomilus Hedley 1913 (*lutaria* Hedley)
976. *cancellatus* Beddome 1882 (*Mangelia*) (733, pl. 35, f. 13)
977. *dyscritus* Verco 1906 (*Terebra*) (764, pl. 36, f. 23)
978. *pentagonalis* Verco 1896 (*Drillia*) (734, pl. 35, f. 14)
979. *spica* Hedley 1907 (*Mangelia*) (765, pl. 36, f. 24)

Gatliffena Iredale 1929 (*fenestrata* Tate and May)
980. *fenestrata* Tate and May 1900 (*Donovania*) (842, pl. 39, f. 25)

Nepotilla Hedley 1918 (*bathentoma* Verco)
981. *bathentoma* Verco 1909 (*Daphnella*) (752, pl. 36, f. 8)
982. *aculeata* May 1915 (*Taranis*) (751, pl. 36, f. 7)
983. *diaphana* May 1919 (753, pl. 36, f. 9)
984. *edwini* Brazier 1894 (*Pleurotoma*) (754, pl. 36, f. 10)
985. *excavata* Gatliff 1906 (*Daphnella*) (755, pl. 36, f. 11)
986. *fenestrata* Verco 1909 (*Daphnella*) (750, pl. 36, f. 6)
987. *lamellosa* Sowerby 1896 (*Clathurella*) (756, pl. 36, f. 12)
988. *microscopica* May 1915 (*Taranis*) (758, pl. 36, f. 18)
989. *minuta* Tenison Woods 1877 (*Drillia*) (pl. 36, f. 16)
990. *mimica* Sowerby 1896 (*Daphnella*) (pl. 36, f. 17)
991. *triseriata* Verco 1909 (*Daphnella*) (760, pl. 36, f. 15)

Pseudodaphnella Boettger 1895 (*philippensis* Reeve)
992. *nodorete* May 1915 (*Clathurella*) (746, pl. 36, f. 2)
993. *mayana* Hedley 1923 (pl. 36, f. 1)

Benthofascus Iredale 1936 (*biconica* Hedley)
994. *sarcinula* Hedley 1905 (*Bathytoma*)

Family: **Conidae**

Floraconus Iredale 1930 (*anemone* Lamarck)
995. *anemone* Lamarck 1810 (*Conus*) (711, pl. 34, f. 16)
996. *peronianus* Iredale 1931

Parviconus Cotton and Godfrey 1932 (*rutilis* Menke)
997. *rutilis* Menke 1842 (*Conus*) (712, pl. 34, f. 15)

Family: **Terebridae**

Terebra Bruguiere (*subulata* Linne)
998. *lauretanae* Tenison Woods 1877 (708, pl. 34, f. 12)

Pervicacia Iredale 1924 (*ustulata* Deshayes)
999. *ustulata* Deshayes 1857 (*Terebra*) (709, pl. 34, f. 14)
1000. *kieneri* Deshayes 1859 (*Terebra*)
1001. *bicolor* Angas 1867 (*Acus*) (705, pl. 34, f. 9)

Nototerebra Cotton 1947 (*albida* Gray)
1002. *albida* Gray 1834 (*Terebra*) (704, pl. 34, f. 8)

Acuminia Dall 1908 (*lanceata* Linne)
1003. *brazieri* Angas 1871 (*Terebra*) (706, pl. 34, f. 10)

Parviterebra Pilsbry 1904 (*paucivolvis* Pilsbry)
1004. *brazieri* Angas 1875 (*Eurypta*) (710, pl. 34, f. 13)

Euterebra Cotton and Godfrey 1932 (*inconspicua* Pritchard and Gatliff)
1005. *inconspicua* Pritchard and Gatliff 1902 (*Terebra*) (707, pl. 34, f. 11)

Sub-class: **Euthyneura**
Order: **OPISTHOBRANCHIA**
Sub-order: **Pleurocoela**
Section: *Bullomorpha*
Super-family: **CEPHALASPIDEA**

Family: **Acteonidae**

Actaeon Montfort 1810 (*tornatilis* Linne)
1006. *retusus* Verco 1907 (946, pl. 44, f. 1)

Bullina Ferussac 1822 (*ziczac* Muhlfeldt)
1006a. *ziczac* Muhlfeldt 1818 (*Voluta*) (1026, pl. 46, f. 20)

Pugnus Hedley 1896 (*parvus* Hedley)
1007. *parvus* Hedley 1896 (1016, pl. 46, f. 10)

Family: **Bullariidae (Quibullidae)**

Quibulla Iredale 1929 (*botanica* Hedley)
1008. *tenuissima* Sowerby 1868 (*Bulla*) (1020, pl. 46, f. 14)
Haminoea Turton 1830 (*hydatis* Linne)
1009. *brevis* Quoy and Gaimard 1833 (*Bulla*) (1022, pl. 46, f. 16)
1009a. *tenera* A. Adams 1850 (*Bulla*) (1023, pl. 46, f. 17)
Cylindrobulla Fischer 1858 (*beauii* Fischer)
1010. *fischeri* Adams and Angas 1864

Family: **Akeridae**

Akera Muller 1776 (*bullata* Muller)
1011. *tasmanica* Beddome 1882 (1021, pl. 46, f. 15)

Family: **Retusidae**

Retusa T. Brown 1827 (*truncatella* Bruguiere)
1012. *amphizosta* Watson 1886 (*Utriculus*) (1009, pl. 46, f. 3)
1013. *apicina* Gould 1859 (*Tornatina*) (1010, pl. 46, f. 4)
1014. *hofmani* Angas 1872 (*Tornatina*) (1011, pl. 46, f. 5)
Volvulella Newton 1891 (*rostrata* A. Adams)
1015. *rostrata* A. Adams 850 (*Bulla*) (1015, pl. 46, f. 9)
Cylichnina Monterosato 1884 (*umbilicata* Montagu)
1016. *atkinsoni* Tenison Woods 1876 (*Cylichna*) (1012, pl. 46, f. 6)
1017. *iredaleana* Hedley 1915 (*Retusa*) (1013, pl. 46, f. 7)
1018. *pygmaea* A. Adams 1854 (*Bulla*) (1014, pl. 46, f. 8)

Family: **Scaphandridae**

Damoniella Iredale 1918 (*cranchii* Fleming)
1019. *exigua* A. Adams 1854 (*Atys*) (1019, pl. 46, f. 13)
Cylichnella Gabb 1872 (*bidentata* d'Orbigny)
1020. *arachis* Quoy and Gaimard 1833 (*Bulla*) (1017, pl. 46, f. 11)
1021. *protumida* Hedley 1903 (*Cylichna* (1018, pl. 46, f. 12)

Family: *Philinidae*

Philine Ascanius 1772 (*aperta* Linne)
1022. *angasi* Crosse & Fischer 1865 (*Bullaea*) (1037, pl. 46, f. 21)
1023. *columnaria* Hedley and May 1908 (1028, pl. 46, f. 22)
1024. *trapezia* Hedley 1902
1025. *teres* Hedley 1902 (pl. 46, f. 23)

Family: **Hydatinidae**

Hydatina Schumacher 1817 (*physis* Linne)
s.g. *Aplustrum* Schumacher 1817 (*amplustre* Linne)
(*Austrodiaphana* Pilsbry 1893 (*brazieri* Angas)
1026. *brazieri* Angas 1877 (*Diaphana*) (1024, pl. 46, f. 18)
s.g. *Hydatina* Schumacher 1817 s. str. (*physis* Linne)
(*Noalda* Iredale 1936 (*exigua* Hedley)
1027. *exigua* Hedley 1912 (1025, pl. 46, f. 20)

Order: PTEROPODA

Sub-order: Thecosomata

Super-family: EUTHECOSOMATA

Family: **Cavoliniidae**

Cavolina Abildgaard 1791 (*tridentata* Forskal)
1028. *inflexa* Lesueur 1813 (*Hyalaea*) (1029, pl. 47, f. 1)
1029. *telemus* Linne 1758 (*Monoculus*) (1030, pl. 47, f. 2)
Diacria Gray 1850 (*trispinosa* Lesueur)
1030. *trispinosa* Lesueur 1821 (*Hyalaea*) (1031, pl. 47, f. 3)
Clio Linne 1767 (*pyramidata* Linne)

1031. *pyramidatus* Linne 1767 (1033, pl. 47, f. 4)
Creseis Rang 1828 (*virgula* Rang)
1032. *virgula* Rang 1828 (1034, pl. 47, f. 6)

Family: **Spiratellidae**

Spiratella Blainville 1817 (*helcina* Phipps)
1033. *inflata* d'Orbigny 1836 (*Atlanta*) (1032, pl. 17, f. 5)

Super-family: APLYSIACEA

Family: **Aplysiidae**

Aplysia Linne 1767 (*depilans* Linne)
1034. *tasmanica* Tenison Woods 1875 (*Aplysia*) (1036, pl. 46, f. 25)

Sub-family: *Dolabriferinae*

Dolabrifera Gray 1847 (*dolabrifera* Cuvier)
1035. *norfolkensis* Sowerby 1869 (*Aplysia*) (1035, pl. 46, f. 24)

Sub-order: Nudibranchia

Super-family: DORIDACEA

Family: **Doridida**e

Sub-family: *Doridinae*

Alloiodoris Bergh 1904 (*marmorata* Bergh)
1036. *marmorata* Bergh 1904 (1038)

Sub-family: *Discodoridinae*

Discodoris Bergh 1877 (*boholiensis* Bergh)
1037. *dubia* Bergh 1904 (1039)
1038. *egena* Bergh 1904 (1040)

Sub-family: *Glossodoridinae*

Glossodoris Ehrenberg, 1831 (*pallida* Ruppell and Leuck)
1039. *tasmaniensis* Bergh 1905 (1041)

Sub-family: *Homoeodoridinae*

Aphelodoris Bergh 1879 (*antillensis* Bergh)
1040. *luctuosa* Bergh 1905 (1042)

Family: **Polyceriidae**

Sub-family: *Onchidoridinae*

Acanthodoris Gray 1857 (*pilosa* Muller)
1041. *metulifera* Bergh 1905 (1043)

Super-family: AEOLIDACEA

Family: **Aeolidiidae**

Sub-family: *Aeolidiinae*

Eolina Quatrefages 1843 (? *angulata* Alder and Hancock)
1042. *faustina* Bergh 1900 (*Aeolidella*) (1037)

Family: **Pleurobranchidae**

Pleurobranchus Cuvier 1804 (*peronii* Cuvier)
1043. *maculatus* Quoy and Gaimard 1833 (*Pleurobranchidium*) (?)

Order: PULMONATA

Sub-order: Basommatophora

Super-family: ACTOPHILA

Family: **Ellobiidae**

Marinula King 1831 (*pepita* King)
s.g. *Maripythia* Iredale 1936 (*xanthostoma* Adams)
1044. *meridionalis* Brazier 1872 (*Alexia*) (863, pl. 40, f. 21)

1045. *parva* Swainson 1856 (*Cremnobates*) (864, pl. 40, f. 22)
1046. *xanthostoma* H. and A. Adams 1854 (865, pl. 40, f. 23)

Leuconopsis Hutton 1814 (*obsoleta* Hutton)
1047. *pellucidus* Cooper 1841 (*Auricula*) (867, pl. 40, f. 25)

Ophicardelus Beck 1837 (*australis* Quoy and Gaimard)
1048. *ornatus* Ferrussac 1821 (*Auricula*) (866, pl. 40, f. 24)

Family: **Onchidiidae**

Onchidella Gray 1850 (*granulosa* Lesson)
1049. *patelloides* Quoy and Gaimard 1832 (868)

Super-family: **AMPHIBOLACEA**

Family: **Amphibolidae**

Salinator Hedley 1900 (*fragilis* Lamarck)
1050. *fragilis* Lamarck 1822 (*Ampullaria*) (869, pl. 41, f. 1)
1051. *solida* Von Martens 1878 (*Amphibola*)

Super-family: **PATELLIFORMIA**

Family: **Gadiniidae**

Gadinalea Iredale 1940 (*conica Angas*)
1052. *conica* Angas 1867 (*Gadinia*) (824, pl. 41, f. 6)

Family: **Siphonariidae**

Siphonaria Sowerby 1824 (*sipho* Sowerby)
s.g. *Hubendicula* McAlpine 1952 (*diemenensis* Quoy and Gaimard)
1053. *diemenensis* Quoy and Gaimard 1833 (*Siphonaria*) (870, pl. 41, f. 2)
s.g. *Talisiphon* Iredale 1940 (*virgulata* Hedley)
1054. *tasmanicus* Tenison Woods 1876 (*Siphonaria*) (872, pl. 41, f. 4)
= *zonata* Tenison Woods
1055. (*tasmanicus*) *turritus* Iredale 1940
s.g. *Ductosiphonaria* Hubendick 1945 (*bifurcata* Reeve)
1056. *funiculata* Reeve 1856 (*Siphonaria*) (871, pl. 41, f. 3)

Pugillaria Iredale 1924 (*stowae* Verco)
1057. *stowae* Verco 1906 (*Kerguelenia*) (873, pl. 41, f. 5)

Super-family: **HYGROPHILA**

Family: **Lymnaeidae**

Austropeplea Cotton 1942 (*papyracea* Tate)
1058. *huonensis* Tenison Woods 1876 (*Limnaea*) (875, pl. 41, f. 7)
1059. *launcestonensis* Tenison Woods 1876 (*Limnaea*)

Limnaea Lamarck 1789 (*stagnalis* Linne)
1060. *peregra* Muller = *hobartonensis* T. Woods 1876 (Introduced)

Simlimnea Iredale 1943 (*brazieri* Smith)
1061. *gunnii* Petterd 1889 (*Limnaea*) (876, pl. 41, f. 8)
1062. *neglecta* Petterd 1889 (*Limnaea*) (877, pl. 41, f. 9)

Family: **Bullinidae**

Lenameria Iredale 1943 (*gibbosa* Gould)
1063. *nitida* Sowerby 1874 (*Physa*) (879, pl. 41, f. 11)
1064. *vandiemenensis* Sowerby 1873 (*Physa*)
1065. *pyramidata* Sowerby 1873 (*Physa*) (881, pl. 41, f. 14)
1066. *pyramidata* variety (pl. 41, f. 15)
1067. *attenuata* Sowerby 1874 (*Physa*) (pl. 41, f. 13)
1068. *brunniensis* Sowerby 1874 (*Physa*)
1069. *mamillata* Sowerby 1874 (*Physa*) (880, pl. 41, f. 12)
1070. *huonensis* Tenison Woods 1876 (*Physa*)

Tasmadora Iredale 1943 (*aperta* Sowerby)
1071. *aperta* Sowerby 1874 (*Physa*) (878, pl. 41, f. 10)
1072. *sorellensis* Cotton 1943.

Family: **Planorbidae**

Pygmanisus Iredale (*scottianus* Johnston)
1073. *scottianus* Johnston 1879 (*Planorbis*) (884, pl. 41, f. 18)
1074. *tasanicus* Tenison Woods 1876 (*Planorbis*) (885, pl. 41, f. 19)

Glyptanisus Iredale 1943 (*ordesessus* Iredale)
1075. *meridionalis* Brazier 1875 (*Planorbis*) (883, pl. 41, f. 17)
1076. *atkinsoni* Johnston 1889 (*Planorbis*) (882, pl. 41, f. 16)
Segnitila Cotton and Godfrey 1938 (*victoriae* Smith)
1077. *victoriae* Smith 1882 (*Segmentina*) (886, pl. 41, f. 20)

Family: **Ancylidae**

Pettancylus Iredale 1943 (*tasmanicus* T. Woods)
1078. *tasmanicus* Tenison Woods 1876 (*Ancylus*) (888, pl. 41, f. 22)
1079. *mariae* Petterd 1902 (*Ancylus*) (887, pl. 41, f. 21)
Problancylus Iredale 1943 (*petterdi* Hedley = *eremia* Cotton and Godfrey)
1080. *petterdi* Johnston 1878 (*Gundlachia*) (890, pl. 41, f. 25)
Legrandia Legrand 1879 (*cumingianus* Bourguignat)
1081. *cumingianus* Bourguignat 1853 (*Ancylus*) (889, pl. 41, f. 23)
1082. *irvinae* Petterd 1888 (*Ancylus*) (pl. 41, f. 24)
1083. *instigata* Iredale 1943

Sub-order: Stylommatophora

Super-family: **SUCCINEACEA**

Family: **Succineidae**

Succinea Drapanaud 1801 (*putris* Linne)
s.g. *Austrosuccinea* Iredale 1937 (*australis* Ferussac)
1084. *legrandi* Legrand 1871 (*Succinea*) (892, pl. 42, f. 2)
1085. var. *queensboroughensis* Petterd 1879 (*Succinea*)
1086. *tamarensis* Petterd 1879 (*Succinea*) (893, pl. 42, f. 3)

Super-family: **VERTIGINACEA**

Family: **Vertiginidae**

Omegapilla Iredale 1937 (*nelsoni* Cox)
1087. *tasmanica* Johnston 1883 (*Pupa*) (891, pl. 42, f. 1)

Super-family: **ZONITACEA**

Family: **Paralaomidae**

Paralaoma Iredale 1913 (*raoulensis* Iredale)
1088. *hobarti* Cox 1868 (*Helix*) (926, pl. 43, f. 12)
1089. *halli* Legrand 1871 (*Helix*) (922, pl. 43, f. 11)
1090. *sitiens* Legrand 1871 (*Helix*)
1091. *tasmaniae* Cox 1868 (*Helix*) (918, pl. 42, f. 18)
1092. *discors* Petterd 1902 (*Helix*)
Laomavix Iredale 1933 (*minima* Cox)
1093. *collisi* Brazier 1877 (*Helix*) (925, pl. 43, f. 10)
1094. *furneauxensis* Petterd 1879 (*Helix*)
Miselaoma Iredale 1933 (*weldii* T. Woods)
1095. *weldii* Tenison Woods 1877 (*Helix*) (931, pl. 43, f. 6)
Pasmaditta Iredale 1933 (*jungermanniae* Petterd)
1096. *jungermanniae* Petterd 1879 (*Helix*) (923, pl. 43, f. 8)
Planilaoma Iredale 1937 (*luckmani* Brazier)
1097. *luckmanii* Brazier 1877 (*Helix*) (924, pl. 43, f. 7)
Trocholaoma Iredale 1937 (*spiceri* Petterd)
1098. *spiceri* Petterd 1879 (*Helix*) (929, pl. 43, f. 14)
1099. *trucanini* Petterd 1879 (*Helix*) (930, pl. 43, f. 9)
1100. *parvissima* Legrand 1871 (*Helix*) (928, pl. 43, f. 13)
Magilaoma Iredale 1937 (*parpictilis* Iredale)
1101. *parpictilis* Iredale 1937 (927, pl. 43, f. 5)
Pedicamista Iredale 1933 (*coesus* Legrand)
1102. *coesa* Legrand 1871 (*Helix*) (921, pl. 43, f. 4)

Family: **Flammulinidae**

Thryasona Iredale 1933 (*diemenensis* Cox)
1103. *diemenensis* Cox 1868 (*Helix*) (935, pl. 43, f. 18)
1104. *thompsoni* Legrand 1871 (*Helix*)
1105. *marchianae* Legrand 1871 (*Helix*) (939, pl. 43, f. 24)

Mulathena Iredale 1933 (*fordei* Brazier)
1106. *fordei* Brazier 1871 (*Helix*) (936, pl. 43, f. 19)
1107. *tranquilla* Legrand 1871 (*Helix*)
Stenacapha Iredale 1933 (*savesi* Petterd)
1108. *savesi* Petterd 1879 (*Helix*) (943)
1109. *kingi* Brazier 1871 (*Helix*)
1110. *hamiltoni* Cox 1868 (*Helix*) (938, pl. 43, f. 22)
1111. *plexus* Legrand 1871 (*Helix*)
1112. *langleyana* Brazier 1875 (*Helix*)
1113. *wynyardensis* Petterd 1879 (*Helix*) (944)

Family: **Charopidae**

Elsothera Iredale 1932 (*sericatula* Pfeiffer)
1114. *limula* Legrand 1871 (*Helix*) (915, pl. 43, f. 2)
1115. *ricei* Brazier 1871 (*Helix*) (914, pl. 43, f. 1)
Discocharopa Iredale 1913 (*exquisita* Iredale)
1116. *vigens* Legrand 1871 (*Helix*)
1117. *bassi* Legrand 1871 (*Helix*) (909, pl. 43, f. 21)
1118. *lottah* Petterd 1879 (*Helix*)
1119. *mimosa* Petterd 1879 (*Helix*) (913, pl. 42, f. 25)
Allocharopa Iredale 1937 (*brazieri* Cox)
1120. *legrandi* Cox 1868 (*Helix*) (912, pl. 42, f. 24)
1121. *kershawi* Petterd 1879 (*Helix*)
Pernagera Iredale 1933 (*albanensis* Cox)
1122. *stanleyensis* Petterd 1879 (*Helix*) (905, pl. 42, f. 16)
1123. *officeri* Legrand 1871 (*Helix*)
1124. *kingstonensis* Legrand 1871 (*Helix*)
1125. *eastbournensis* Hedley 1892 (*Charopa*)
1126. *architectonica* Legrand 1871 (*Helix*) (907, pl. 42, f. 19)
1127. *tamarensis* Petterd 1879 (*Helix*) (917, pl. 42, f. 17)
Kannaropa Iredale 1937 (*subrugosa* Legrand)
1128. *subrugosa* Legrand 1871 (*Helix*) (916, pl. 43, f. 3)
Egilomen Iredale 1937 (*cochlidium* Cox)
1129. *barrenense* Petterd 1879 (*Helix*) (908, pl. 42, f. 20)
Dentherona Iredale 1933 (*dispar* Brazier)
1130. *dispar* Brazier 1871 (*Helix*) (910, pl. 42, f. 22)
Geminoropa Iredale 1933 (*antialba* Beddome)
1131. *antialba* Petterd 1879 (*Helix*) (906, pl. 42, f. 15)
1132. *hookeriana* Petterd 1879 (*Helix*) (911, pl. 42, f. 23)
Oreomava Iredale 1933 (*otwayensis* Petterd)
1133. *johnstoni* Iredale 1933 (941, pl. 43, f. 21)
Bischoffena Iredale 1937 (*bischoffensis* Petterd)
1134. *bischoffensis* Petterd 1879 (*Helix*) (933, pl. 43, f. 16)
Roblinella Iredale 1937 (*roblini* Petterd)
1135. *roblini* Petterd 1879 (*Helix*) (942, pl. 43, f. 25)
1136. *gadensis* Petterd 1879 (*Helix*) (937, pl. 43 , f. 20)
1137. *curacoae* Brazier 1871 (*Helix*) (934, pl. 43, f. 17)
1138. *mathinnae* Petterd 1879 (*Helix*) (940, pl. 43, f. 23)
1139. *agnewi* Legrand 1871 (*Helix*) (932, pl. 43, f. 15)

Super-family: **ARIOPHANTACEA**

Family: **Helicarionidae**

Helicarion Ferussac 1821 (*cuvieri* Ferussac)
1140. *cuvieri* Ferussac 1821 (945, pl. 43, f. 26)

Family: **Cystopeltidae**

Cystopelta Tate 1881 (*petterdi* Tate)
1141. *petterdi* Tate 1881 (920)
1142. *bicolor* Petterd and Hedley 1909 (919)

Super-family: **ACAVACEA**

Family: **Caryodidae**

Caryodes Albers 1850 (*dufresnii* Leach)
1143. *dufresnii* Leach 1815 (*Bulimus*) (895, pl. 42, f. 5)
1144. (*dufresnii*) *superior* Iredale 1937

1145. (*dufresnii*) extra Iredale 1937
1146. (*dufresnii*) dertra Iredale 1937

Family: **Anoglyptidae**

Anoglypta Martens 1861 (*launcestonensis* Reeve)
1147. *launcestonensis* Reeve 1853 (*Helix*) (894, pl. 42, f. 4)

Super-family: **BULIMULACEA**

Family: **Bothriembryontidae**

Tasmanembryon Iredale 1933 (*tasmanicus* Pfeiffer)
1148. *tasmanicus* Pfeiffer 1853 (*Bulimus*) (897, pl. 42, f. 7)

Super-family: **HELICACEA**

Family: **Hadridae**

Chloritobadistes Iredale 1933 (*victoriae* Cox)
1149. *victoriae* Cox 1868 (*Helix*) (896, pl. 42, f. 6)

Super-family: **STREPTAXACEA**

Family: **Paryphantidae**

Melavitrina Iredale 1933 (*milligani* Pfeiffer)
1150. *milligani* Pfeiffer 1854 (*Vitrina*) (903, pl. 42, f. 13)
1151. *fumosa* Tenison Woods 1878 (*Helicarion*)
Prolesophanta Iredale 1933 (*dyeri* Petterd)
1152. *dyeri* Petterd 1879 (*Helix*) (902, pl. 42, f. 12)
Tasmaphena Iredale 1933 (*sinclairi* Pfeiffer)
1153. *sinclairi* Pfeiffer 1845 (*Helix*) (901, pl. 42, f. 11)
Tasmadelos Iredale 1938 (*nelsonensis* Brazier)
1154. *nelsonensis* Brazier 1871 (*Helix*) (904, pl. 42, f. 14)
1155. (*nelsonensis*) abitens Iredale 1938

Family: **Rhytidae**

Strangesta Iredale 1933 (*leichardti* Cox)
1156. *lampra* Reeve 1854 (*Helix*) (898, pl. 42, f. 8)
1157. *lamproides* Cox 1868 (*Helix*) (899, pl. 42, f. 9)
1158. *ruga* Legrand 1871 (*Helix*) (900, pl. 42, f. 10)

Class: CEPHALOPODA

Sub-class: Dibranchia

Order: OCTOBRANCHIATA

Family: **Octopodidae**

Octopus Lamarck 1798 (*vulgaris* Lamarck)
1159. *pallidus* Hoyle 1885 (224)
Haplochaena Robson 1929 (*lunulatus* Quoy and Gaimard)
1160. *maculosa* Hoyle 1883 (*Octopus*) (223)

Family: **Argonautidae**

Argonauta Linne 1756 (*argo* Linne)
1161. *nodosa Solander* 1786 (225, pl. 13, f. 5)

Order: DECACERATA

Family: **Spirulidae**

Spirula Lamarck 1799 (*spirula* Linne)
1162. *spirula* Linne 1758 (216, pl. 13, f. 4)

Family: **Omnastrephidae**

Notodarus Pfeiffer 1912 (*insignis* Gould)
1163. *gouldi* McCoy 1888 (*Omnastrephes*) (221)

Sub-order: Myopsidae

Family: Sepiolidae

Euprymna Steenstrup 1887 (*morsei* Verrill)
1164. *tasmanica* Pfeiffer 1884 (*Sepiola*) (220)

Family: Sepiidae

Sub-family: *Solitosepiinae*

Mesembrisepia Iredale 1926 (*macandrewi* Iredale)
1165. *novaehollandiae* Hoyle 1909 (*Sepia*)
1166. *ostanes* Iredale 1954
1167. *macandrewi* Iredale 1926 (?)
Amplisepia Iredale 1926 (*apama* Gray)
1168. *apama* Gray 1849 (*Sepia*) (217, pl. 13, f. 1)
Decorisepia Iredale 1926 (*rex* Iredale)
1169. *rex* Iredale 1926
Glyptosepia Iredale 1926 (*opipara* Iredale)
1170. *hedleyi* Berry 1918 (*Sepia*)
1171. *gemellus* Iredale 1926 (219, pl. 13, f. 2, ?)

Sub-family: *Doratosepiontinae*

Arctosepia Iredale 1926 (*limata* Iredale)
1172. *braggi* Verco 1901 (*Sepia*) (218, pl. 13, f. 3)
1173. (*braggi*) *xera* Iredale 1954
1174. *treba* Iredale 1954

Class: SCAPHAPODA

Family: Dentaliidae

Dentalium Linne 1758 (*elaphantinum* Linne)
s.g. *Paradentalium* Cotton and Godfrey 1933 (*bednalli* Pilsbry and Sharp)
1175. *tasmaniensis* Tenison Woods 1877 (1044)
1176. *weldianum* Tenison Woods 1877 (1046, pl. 47, f. 8)
s.g. *Episiphon* Pilsbry and Sharp 1897 (*sowerbyi* Guilding)
1177. *virgula* Hedley 1903 (1045, pl. 47, f. 7)

Family: Siphonodentaliidae

Cadulus Philippi 1841 (*ovalum* Philippi)
s.g. *Gadila* Gray 1847 (*gadus* Montagu)
1178. *vincentianus* Cotton and Godfrey 1940 (1047, pl. 47, f. 9)
1179. *spretus* Tate and May 1900 (1048, pl. 47, f. 10)

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